
# North Fork River

*Watershed and Inventory Assessment, April 2001*

*Prepared by Scott M. Miller, Fisheries Management Biologist and Thomas F. Wilkerson Jr., Fisheries Biologist*

*Missouri Department of Conservation, West Plains, Missouri*

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# Executive Summary

The North Fork of the White River Watershed, henceforth referred to in this document as the North Fork Watershed, in Missouri occupies approximately 1,389 (888,960) square miles in parts of six counties in the Southern Missouri Ozarks. These counties include Douglas, Howell, Ozark, Texas, Webster, and Wright. The North Fork Watershed in Missouri constitutes approximately 76% of the total area of the North Fork Watershed with the remainder in Arkansas. The watershed is bound on the north by the Gasconade and the Big Piney Watersheds; on the east by the Jack's Fork, Eleven Point, and Spring River Tributaries Watersheds; and to the west by the White River Tributaries (Bull Shoals Reservoir) Watershed and the James Watershed. For the purposes of this document, the Missouri/Arkansas State Line represents the southern boundary of the watershed. Two major streams drain the North Fork Watershed. These are the North Fork of the White River and Bryant Creek. The North Fork of the White River originates in the vicinity of Mountain Grove in southeastern Wright County. The river flows in a general southerly direction across Douglas and Ozark counties for 67 miles before emptying into Northfork Reservoir near Tecumseh, Missouri. Northfork Reservoir is a 22,000 acre (at conservation pool) United States Army Corps of Engineers reservoir. The North Fork of the White River is joined by Bryant Creek approximately one half mile north of Tecumseh, Missouri. Bryant Creek, the largest tributary to the North Fork of the White River, originates near Cedar Gap in southwestern Wright County. Bryant Creek flows southeasterly across Douglas and Ozark counties for 71 miles before emptying into the North Fork River.

The geology of the North Fork Watershed is composed primarily of sandstones and dolomites of Ordovician and Mississippian age. Caves, springs, losing streams, and sinkholes are common in the watershed, due to the highly karst nature of its topography. There are 283 springs within the watershed as determined from USGS 7.5 minute topographic maps. The largest of these springs are Double (Rainbow) and North Fork Springs which emerge close together on the North Fork River. The watershed lies within the Ozark Soils Region. Using United States Geological Survey (USGS) 7.5 minute topographic maps, a total of 139 third order (Horton) and larger streams were identified within the North Fork Watershed.

The North Fork River, a seventh order stream, is the highest order stream within the watershed. Approximately 276 miles of third order and larger streams have permanent flow. Stream channel gradients were determined for all fourth order and larger streams within the watershed. The North Fork River has an average gradient of 12.8 ft. per mile.

Land use/land cover within the North Fork Watershed primarily consists of grassland/cropland (37.5%) and forest/woodland (61.9%). Urban areas make up 0.4% of the watershed. The watershed has two urban areas with a population of over 1,000 persons. These are Ava, Missouri (population 2,938) and Mansfield, Missouri (population 1,429). The population density of the watershed is approximately 43 persons per square mile. The North Fork Watershed is dissected by several transportation routes. These include six major state routes and one U.S. highway. In addition, one rail line intersects the watershed for a short distance on the watershed's eastern edge. Approximately 13.1% of the watershed is in public ownership; 88% of which is managed by the United States Forest Service.

Average annual precipitation within the North Fork Watershed is 43.26 inches. The United States Geological Survey (USGS) currently (1999) has two active surface discharge gauge stations within the watershed. Data from these stations indicate average daily flows for the North Fork River near Tecumseh and Bryant Creek near Tecumseh are 756 cubic feet per second (cfs) and 534 cfs respectively.

Water quality within the North Fork Watershed is relatively good; however periodically high fecal coliform levels, nutrient loading, and sediment/gravel deposition are threats to water quality. Gravel dredging, indiscriminate land clearing, and the presence of livestock in riparian zones for extended

periods of time are some causes of the water quality problems. In addition, the potential contamination of the ground water system by septic systems as well as municipal discharges to losing streams is also of concern. There is one municipal waste water discharge within the watershed. Eight additional National Pollution Elimination System discharges are also located within the watershed.

Four minor, but notable, water control structures exist within the watershed. The only water control structure on the North Fork River in Missouri is Dawt Mill Dam. This is a relatively low structure (less than eight feet high) located approximately 1.8 mile above Tecumseh Missouri. Condition of stream habitat within the North Fork Watershed is relatively good in most areas. Analysis of quantified Stream Habitat Assessment Device (SHAD) results from 13 sites within the watershed indicates that habitat at these sites range from 'fair' to 'excellent'. Riparian corridor land cover/land use within the watershed consists of more forest/woodland (64.9%) than grassland/cropland (34.2%). Small channelization projects have probably occurred on private and municipal property and also during road and bridge construction.

The biotic community of the North Fork Watershed is diverse. Seventy-six species of fish, 21 species of mussels, 15 species of snails, 5 species of crayfish, and 106 taxa of benthic invertebrates have been collected within the watershed. Several species of sport fish occur within the watershed including grass pickerel, chain pickerel, rainbow trout, brown trout, Ozark bass, smallmouth bass, largemouth bass, channel catfish, warmouth, walleye, spotted bass, flathead catfish, black crappie, white crappie, striped bass, and white bass. In addition, a total of 65 "species of conservation concern" are known to occur within the watershed. Three species have federal endangered and state endangered species status. These include the gray bat, Indiana Bat, and running buffalo clover. An additional 4 species have state endangered species status. These are the mountain lion, black-tailed jackrabbit, Bachman's Sparrow, and Swainson's Warbler. The bald eagle is listed as a federal threatened species and a state endangered species. It is currently proposed for delisting.

The management goals, objectives, and strategies for the North Fork Watershed were developed using information collected from the North Fork Watershed Assessment and Inventory (WAI). Objectives and strategies were written for instream and riparian habitat, water quality, aquatic biota, and recreational use. All goals are of equal importance. These goals include:

- Improve riparian and aquatic habitats in the North Fork Watershed,
- Improve surface and subsurface water quality and quantity in the North Fork Watershed,
- Maintain the abundance, diversity, and distribution of aquatic biota at or above current levels while improving the quality of the sport fishery in the North Fork Watershed,
- Increase public awareness and promote wise use of aquatic resources in the North Fork Watershed.

The attainment of these goals will require the acceptance and cooperation of private landowners, other divisions within the Missouri Department of Conservation, as well as other state and federal agencies.

## Location

The North Fork of the White River originates in the vicinity of Mountain Grove in Southeastern Wright County. The river flows in a general southerly direction across Douglas and Ozark counties for 67 miles before emptying into Norfork Reservoir near Tecumseh, Missouri. Norfork Reservoir is a 22,000 acre (at conservation pool) United States Army Corps of Engineers reservoir. The North Fork of the White River is joined by Bryant Creek approximately one half mile north of Tecumseh, Missouri. Bryant Creek, the largest tributary to the North Fork of the White River, originates near Cedar Gap in southwestern Wright County. Bryant Creek flows southeasterly across Douglas and Ozark counties for 71 miles before emptying into the North Fork River.

The North Fork Watershed occupies 1,389 square miles in parts of six counties in the Southern Missouri Ozarks. These counties include Douglas, Howell, Ozark, Texas, Webster, and Wright. The watershed is bound on the north by the Gasconade and the Big Piney Watersheds; on the east by the Jack's Fork, Eleven Point, and Spring River Tributaries Watersheds; and to the west by the White River Tributaries (Bull Shoals Reservoir) Watershed and the James Watershed. For the purposes of this document, the Missouri/Arkansas State Line represents the southern boundary of the watershed unless otherwise stated (Figure Bk01).

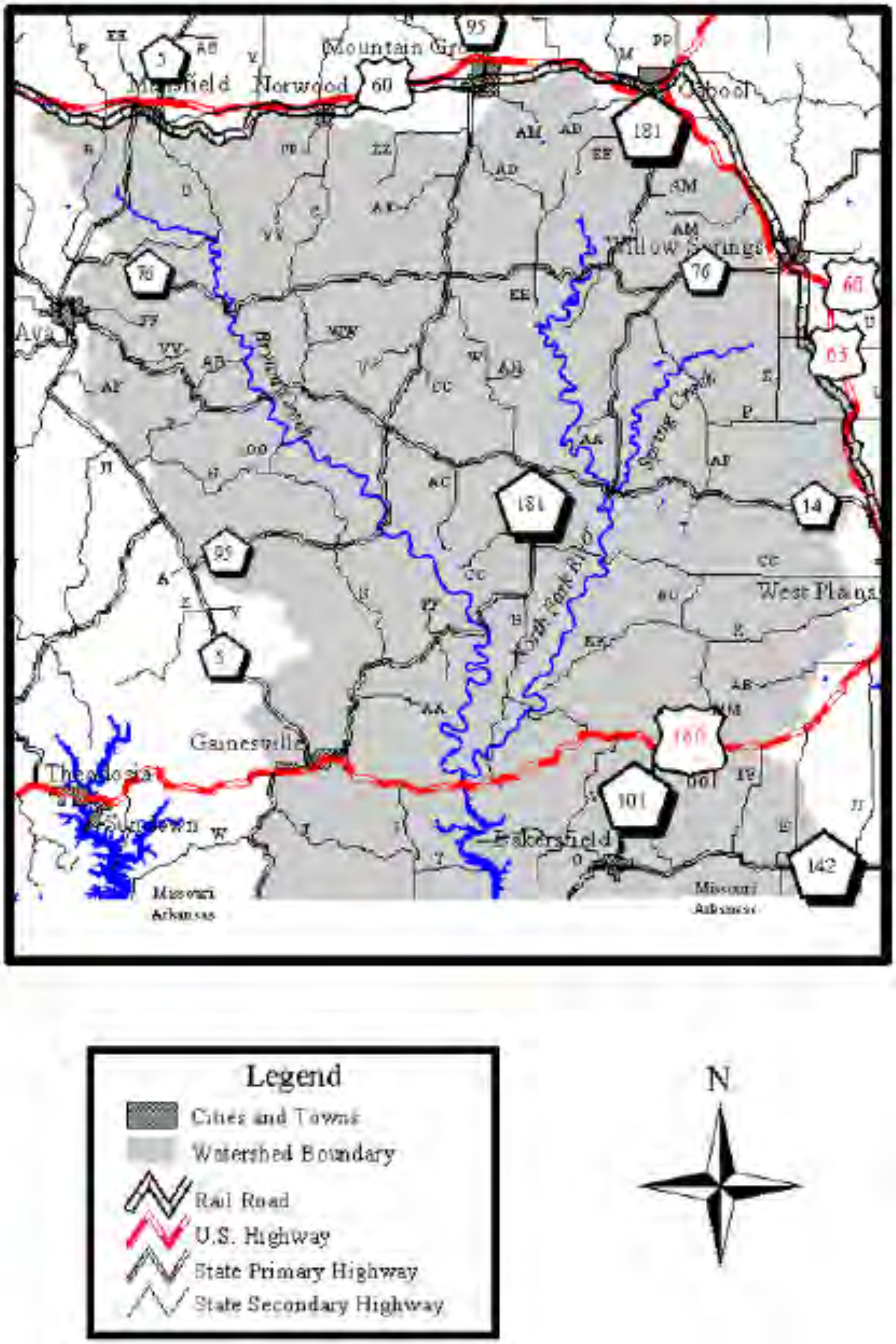
The North Fork Watershed has two cities with a population of over 1,000 persons. These are Ava, Missouri (population 2,938) and Mansfield, Missouri (population 1,429) (MSCDC 1997). Both cities are only partially within the watershed. Two towns with populations of over 250 persons are completely within the watershed. These are Bakersfield (population 292) and Gainesville (population 659)

The North Fork Watershed is dissected by several transportation routes. These include six major state routes and one U.S. highway. In addition, one rail line intersects the watershed for a short distance on the watershed's eastern edge (Figure Bk02).

North Fork Watershed
Location
N
Mountain Grove
Mansfield
Norwood
60
Texas
63
Cabool
Wright
Willow Springs
Ava
Douglas
Howell
160
West Plains
Ozark
Gainesville
Bakersfield
Bull Shoals Reservoir
Norfork Reservoir
Legend
Cities and Towns
North Fork Watershed
County Boundary
Adjacent Watersheds
5 0 5 10 Miles

Figure Bk02.

# North Fork Watershed
## Infrastructure



# Geology

## Physiographic Location

The North Fork Watershed lies within the Salem Plateau Subdivision of the Ozark Plateau Physiographic Region. The Salem Plateau is an ancient uplift plain long exposed to the dissecting action of streams. The North Fork Watershed is located in "one of the most rugged portions of the Missouri Ozarks" (Smith 1990). Stream dissection following successive Paleozoic uplifts has created a landscape of steep ridges and high bluffs bordering the deeply entrenched drainage. Elevations range from a maximum of approximately 1660 feet above mean sea level (msl) near Cedar Gap, Missouri to 554 feet above msl (the level of Norfork Lake at conservation pool). Local relief data (Local relief refers to the difference in elevation between two nearby points such as a valley and an adjoining ridge top) obtained from the Missouri Department of Conservation (MDC) Fisheries Research Fish Collection Database (1998a) for fish collection sites within the watershed indicate a minimum of 171 feet at a site located on Middle Indian Creek and a maximum of 378 feet at a sample site located on lower Bryant Creek. The North Fork Watershed is also characterized by prominent karst features, such as caves, springs, sinkholes, and losing streams.

## Geology

The surface of the North Fork Watershed lies entirely in dolomites and sandstones of Ordovician and Mississippian Age (Figure Ge01). The surface geology of the uplands of the watershed lie in Jefferson City dolomite. Sandstone and dolomite of the Roubidoux Formation make up the geology of most of the stream valleys (MDNR 1994). The more acidic residuum resulting from the weathering of Roubidoux strata has allowed the shortleaf pine (Pinus schinata) to become a prominent forest component of the uplands of eastern Douglas and Ozark counties. In the middle and lower parts of the watershed, dolomites of the Gasconade formation are exposed. It is from this strata that most of largest springs of Missouri, as well as the North Fork Watershed, have developed (MDNR 1994).

## Soils

The North Fork River Watershed occurs within the Ozarks Soil Region. Allgood and Persinger (1979) describe the Ozark Soils Region as "cherty limestone ridges that break sharply to steep side slopes of narrow valleys. Loess occurs in a thin mantle or is absent. Soils formed in the residuum from cherty limestone or dolomite range from deep to shallow and contain a high percentage of chert in most places. Some of the soils formed in a thin mantle of loess are on the ridges and have fragipans, which restrict root penetration. Soil mostly formed under forest vegetation with native, mid-tall and tall grasses common in open or glade area."

The following is a list of soil associations found in the North Fork Watershed:

- **Captina-Clarksville-Doniphan:** "Nearly level to very steep, moderately well drained to excessively drained loamy upland soils that have fragipans or soils that are cherty throughout." (Allgood and Persinger 1979)
- **Captina-Macedonia-Doniphan-Poynor:** "Nearly level to very steep well drained and moderately well drained, loamy upland soils that have fragipans or soils that are cherty throughout." (Allgood and Persinger 1979)
- **Hartville-Ashton-Cedar Gap-Nolin:** "Deep, nearly level to gently sloping, somewhat poorly drained to excessively drained, loamy bottom land soils." (Allgood and Persinger 1979)

- **Lebanon-Hobson-Clarksville:** "Gently sloping to very steep, moderately well drained to somewhat excessively drained, loamy and clayey soils with fragipans or soils that are cherty **throughout." (Allgood and Persinger 1979)**
- **Wilderness-Clarksville-Coulstone:** "Gently sloping to very steep, moderately well drained to excessively drained, loamy upland soils that have cherty subsoils or fragipans." (Allgood and Persinger 1979)

## Stream Order, Mileage, Permanency, and Springs

Stream order is "a hierarchy in which stream segments are arranged" (Judson et al. 1987)

The process of stream ordering is accomplished by examining maps and assigning orders to stream segments based on other streams which flow into them. When two stream segments of the same order join, the new segment they create is the next highest order. For instance, a first order stream would be a stream in which no other streams intersect it. A second order stream is created by the joining of two first order streams. A third order stream is created by the joining of two second order streams and so on. If the main channel of a stream happens to be a lower order than that of the intersecting stream, the main channel assumes the higher order. If the main channel is a higher order stream than the intersecting stream, it maintains the higher order (Figure Ge02). Two types of order are discussed within this document: Horton order which is the maximum order of a stream at its mouth; and Strahler order which is the immediate order of a stream at any given segment of its length. For instance, the Strahler order of No Name Creek at point A in Figure Ge02 is second order while the Horton Order for the main channel designated as No Name Creek is third order. Unless otherwise stated, order references will refer to Horton order.

Using United States Geological Survey (USGS) 7.5 minute topographic maps, a total of 139 third order and larger streams were identified within the North Fork Watershed (Table Ge01). Of these 27 occur within the Norfork Reservoir Drainage; 56 occur in the North Fork River Drainage above Bryant Creek; and 56 occur within the Bryant Creek Subwatershed. Of the 139 third order and larger streams within the watershed, 104 are third order, 23 are fourth order, 9 are fifth order, and 2 are sixth order. The North Fork River becomes seventh order at the confluence of Spring Creek, approximately 1.5 river miles below Highway 14 in Ozark County (Figures Ge03, Ge04, Ge05).

Third order and larger streams account for approximately 972.1 miles of stream channel within the North Fork Watershed. Of the 972 stream miles, third order streams account for the most stream miles at 431.4, while fourth, fifth, sixth, and seventh order streams account for 224.4, 160.4, 89.3, and 66.6 stream miles respectively.

Stream mileage per order (Strahler) for fifth order and larger streams was determined using data digitized from USGS 7.5 minute topographic maps (Table Ge02). Fifth order segments account for most of the stream miles at 108. Seventh order stream segments account for the least amount of stream miles at 11.

Third order and larger streams within the North Fork Watershed were classified as permanent or intermittent as indicated on USGS 7.5 minute topographic maps. It should be noted that standard series as well as provisional series maps were used. Attributes for denoting permanent vs. intermittent flow were different between standard and provisional series maps. Further, it appeared as though the length of permanent stream was greater among the standard series maps. This information was amended to reflect data obtained from stream field observations performed by MDC Ozark Region Fisheries Personnel during July and August of 1990-1994 (Figures Ge03-05). It is estimated that of a total of 972 miles of third order and larger streams, 276 miles (28.4%) have permanent flow. The remaining 696 miles are intermittent streams, some perhaps having permanent pools capable of supporting aquatic life. Table Ge01 gives estimated length of permanent water as well as total length for individual third order and larger streams in the watershed.

The geology of the North Fork Watershed combined with an average precipitation of over 40 inches annually have created a karst landscape. Features of this landscape include losing streams, sinkholes, deeply intrenched valleys, and springs. It is believed that a large amount of water from the Bryant Creek Subwatershed is lost to the ground water system and emerges from Double and North Fork Springs. This is assumed due to the fact that low flows within the North Fork River are approximately twice those of Bryant Creek although the drainage areas of both are similar in size (MDNR 1994).

The Missouri Department of Natural Resources (1996a) has designated approximately 177 miles of streams within the watershed as "losing" (Table Ge03). Figure Ge06 shows losing streams within the North Fork Watershed as well as smaller streams that drain into these. These smaller streams are included because, although not officially designated as losing, they flow into losing stream reaches and thus also contribute to the loss of surface water to the ground water system. These losing streams, as well as sinkholes, recharge many springs within the watershed as well as some outside of the watershed including Mammoth Spring within the Spring River Watershed in Arkansas. This has been confirmed by several ground water dye tracings performed by the U.S. Forest Service and Missouri Department of Natural Resources between 1971 and 1989 (Figure Ge06; MDNR 1996b). These traces indicate that Hodgson Mill Spring, Double (Rainbow) Spring, and North Fork Spring, receive a portion of their recharge from losing streams in the Upper Gasconade Watershed including Wolf Creek, Fry Creek, and Lick Fork. This ground water travels a maximum linear horizontal distance of 38.9 miles and drops a maximum vertical distance of 655 feet between the tributaries of the Upper Gasconade and the aforementioned springs. These springs are also recharged by sinkholes and losing streams within the North Fork Watershed itself. This data would indicate that North Fork, Hodgson Mill, and Double (Rainbow) Springs are the outlet of a vast ground water system. Heavy growths of algae in North Fork and Double Spring suggest the existence of nutrient rich waters within the recharge area of these springs (MDNR 1994). Waste water from the Mansfield Waste Water Treatment Plant is discharged into a tributary of Fry Creek which, itself, is a tributary of Wolf Creek. As stated previously, water from both streams emerges from Double, North Fork, and Hodgson Mill Springs. The boundary between the Gasconade and the North Fork Watersheds is part of the major boundary between rivers within the Missouri River Drainage and the White River Basin. Groundwater travel across this boundary thus illustrates the common contrast between surface and groundwater movement.

Within the North Fork Watershed there are 283 springs as determined from United States Geological Survey 7.5 minute topographical maps. Vineyard and Feder (1974) list discharges for 16 of these springs (Figure Ge07 and Table Ge04). The two largest springs within the watershed are Double (Rainbow) and North Fork Springs, which emerge close together on the lower North Fork River. These have a combined flow of nearly 200 cfs. Hodgson Mill Spring is the third largest spring in the watershed with an average flow of 36 cfs. As discussed earlier all three springs appear to have the same recharge area. In addition, five other springs within the watershed have average discharges greater than 10 cfs (Vineyard and Feder 1974).

Base flows to streams are well maintained during dry periods within the North Fork Watershed. The watershed is second only to the Current River Watershed in the size of its base flow (MDNR 1994). A comparison of base flows from watersheds of differing sizes is accomplished by comparing drainage area to low flow ratios (as given by MDNR 1994) of streams surrounding the watershed. The North Fork ranks second to the Current River at 4.5 square miles for every cubic feet per second (cfs) of flow. The Current river has the lowest ratio at 2.6:1. The James River has the highest ratio at 32.3:1

## Drainage Area

The drainage area of the North Fork Watershed is 1389 square miles or 888,928 acres. The North Fork Watershed is divided into 6 eleven digit hydrologic units(HU). These are further divided into smaller fourteen digit hydrologic units of which there are 30 within the watershed (Figure Ge08). The largest

eleven digit HU in the watershed is the Lower North Fork Unit with an area of 358 square miles (228,822 acres). The largest fourteen digit HU is 11010006040004 with an area of 84 square miles (53,731 acres). It is located in the Lower Bryant eleven digit hydrologic unit. In karst regions, such as the North Fork Watershed, it is of equal importance to understand the ground water divisions. As discussed earlier, it is believed that the recharge area of Double (Rainbow) and North Fork Springs include portions of the drainage area of Bryant Creek (MDNR 1994). In addition, dye traces indicate the watershed not only receives ground water from at least one other watershed but also loses ground water to at least one neighboring watershed (MDNR 1996b).

## Channel Gradient

Channel gradient was determined using data digitized from USGS 7.5 minute topographic maps for all fourth order and larger streams within the North Fork River Watershed. Composite gradient plots were constructed for all fifth order and larger streams within the watershed. Channel gradient graphs were constructed using the formula (CHANGE IN ELEVATION/CHANGE IN MILEAGE). While this formula proved adequate to graph the actual gradient of a stream, it was not used to calculate the average gradient for the entire stream. This is due to the fact that gradients were determined at increments of 20 ft changes in elevation and not mileage. Therefore, a single gradient value could have a disproportionate effect on the average gradient of an entire stream if an average of all calculated gradients were used to represent the average gradient of an entire stream. For this reason, average gradient as well as gradient for order (Strahler) was determined using the formula (TOTAL CHANGE IN ELEVATION/TOTAL CHANGE IN MILEAGE). This formula yielded a linear graph which, while it did not yield a realistic graphic representation, did produce an adequate calculation of average gradient for an entire stream.

Average gradients, as well as gradient for strahler order of streams fifth order (horton) and larger are given in Table Ge05. The North Fork River has an average gradient of 12.8 feet/mile. While Bryant Creek has an average gradient of 14.1 feet/mile.

Figure Ge01.

# North Fork Watershed
## Geology

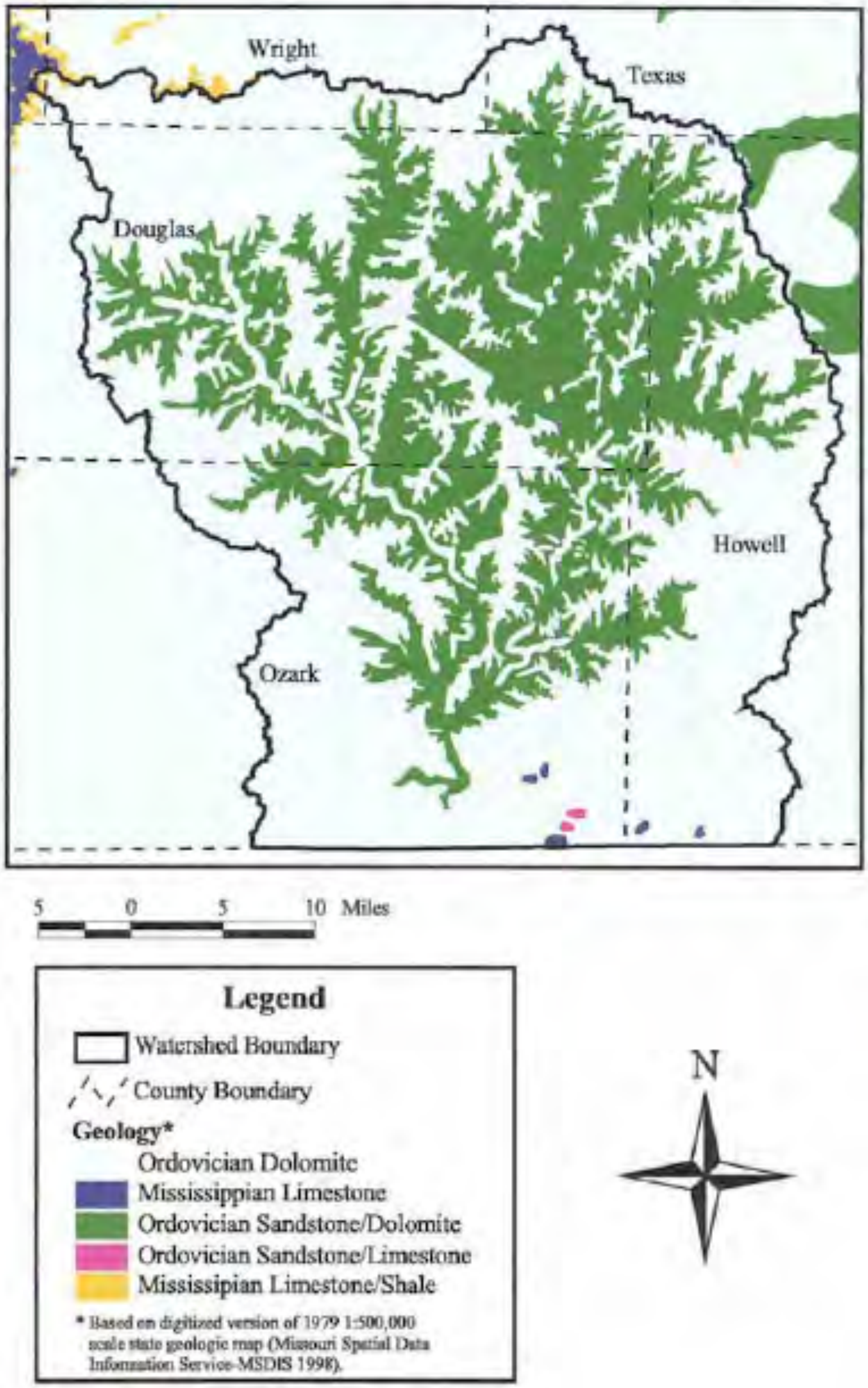
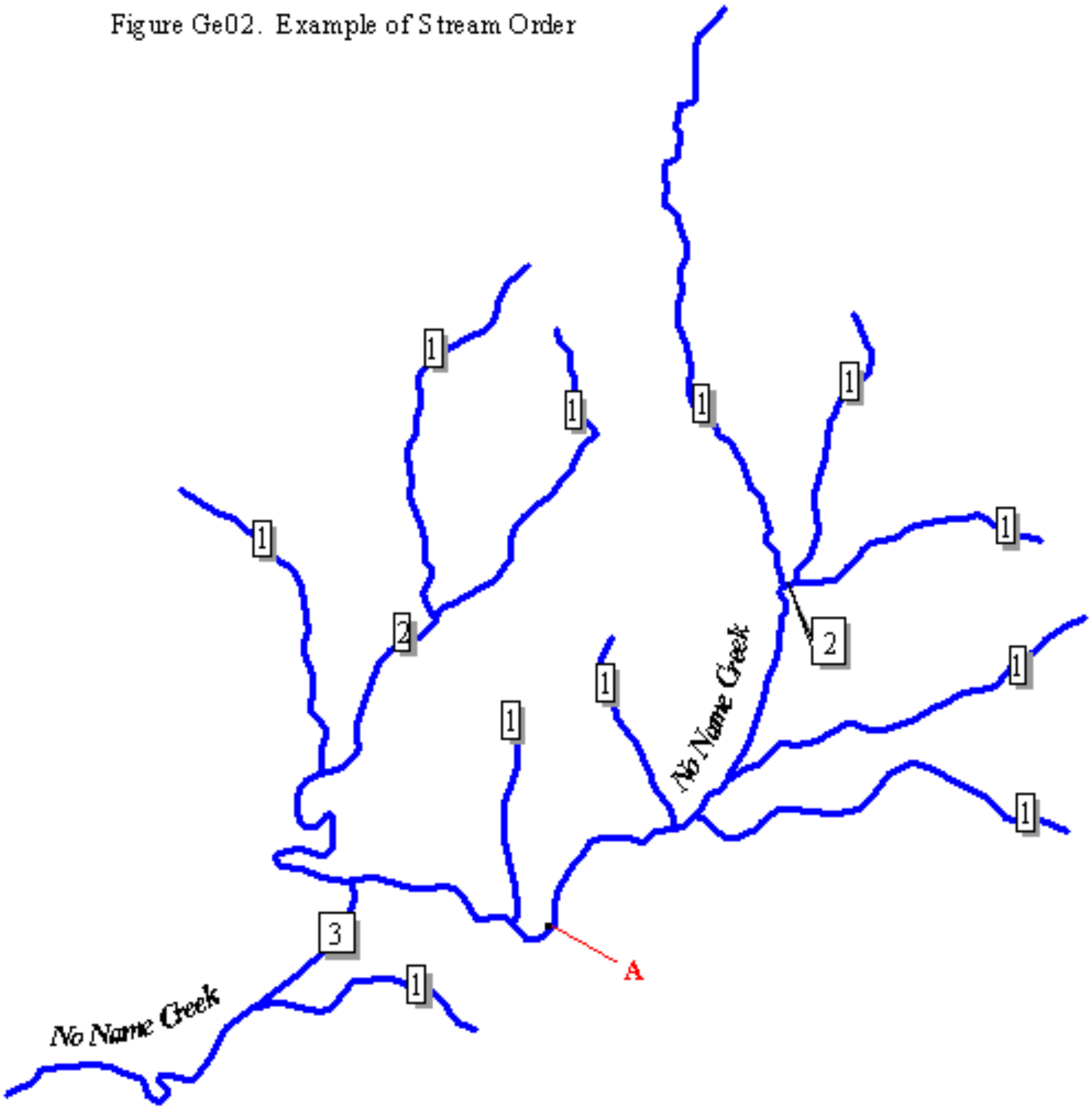


Figure Ge02. Example of Stream Order




The stream segment at Point A has a Horton order of 3 and a Strahler order of 2.


Upper North Fork
Third Order and Larger Streams
Panther Cr.
Middle Indian Cr.
Little Indian Cr.
Little Cr.
Hungry Cr.
024
Greasy Cr.
East Cliffy Cr.
023
Red Bank
North Fork
Indian Cr.
Crooked Cr.
Brushy Cr.
Noblett Cr.
N.F. Spr.
N.F. Dry Cr.
Cliffy Cr.
Cord Hl.
S.F. Spr.
Jim Coble Hl.
022
Prairie Hl.
Kenyon Hl.
021
Robinson Hl.
Spring Cr.
Dry Cr.
019
Zach's Br.
N
Tabor Cr.
020
018
017
Mary's Hl.
016
015
Crooked Br.
Tabor Cr.
Fox Hl.
013
Joe Pond Hl.
014
Spring Cr.
Davis Cr.
011
Ruth Hl.
Setzer Br.
Wilson Cr.
012
010
Smith Hl.
Sheriff Hl.
Willow Cr.
Bridges Br.
Key Map
4 0 4 8 Miles
Legend
Unit Boundary
Permanent Stream*
Intermittent Stream*

Figure Ge04.


Bryant Creek
Third Order and Larger Streams
Prairie Hl.
Puncheon Camp Cr.
Bryant Cr.
Dry Cr.
S.F. Dry Cr.
E. Prong
Panther Hl.
Bill Mack's Cr.
Camp Cr.
Wolfpen Hl.
Clever Cr.
Bluegrass Hl.
Hunter Cr.
Greasy Cr.
Wildcat Cr.
Wilson Hl.
White's Cr.
West Fork
Jack's Fork
Coonts Hl.
Pedro Hl.
Rippee Cr.
Fox Cr.
L. Brush Cr.
Strong Spring Br.
Boiler Hl.
Brush Cr.
Smith Hl.
Spring C.
Dry Cr.
Burgess Hl.
Brown Hl.
Smith Cr.
Gardner Hl.
Key Map
Nance Cr.
Spring Cr.
Brixey Cr.
Owens Hl.
Hurricane Cr.
Trail Cr.
Bollinger Br.
Cane Bottom Hl.
Lottis Hl.
Holdman Hl.
Caney Cr.
Pine Cr.
Wiedemann Hl.
L. Pine Cr.
4 0 4 8 Miles
Legend
Unit Boundary
Permanent Stream*
Intermittent Stream*
* Based on 1:100,000 GIS State Hydrography Layer and USGS 7.5' Topographical Maps.
N

Figure Ge05.

## Norfork Reservoir
### Third Order and Larger Streams

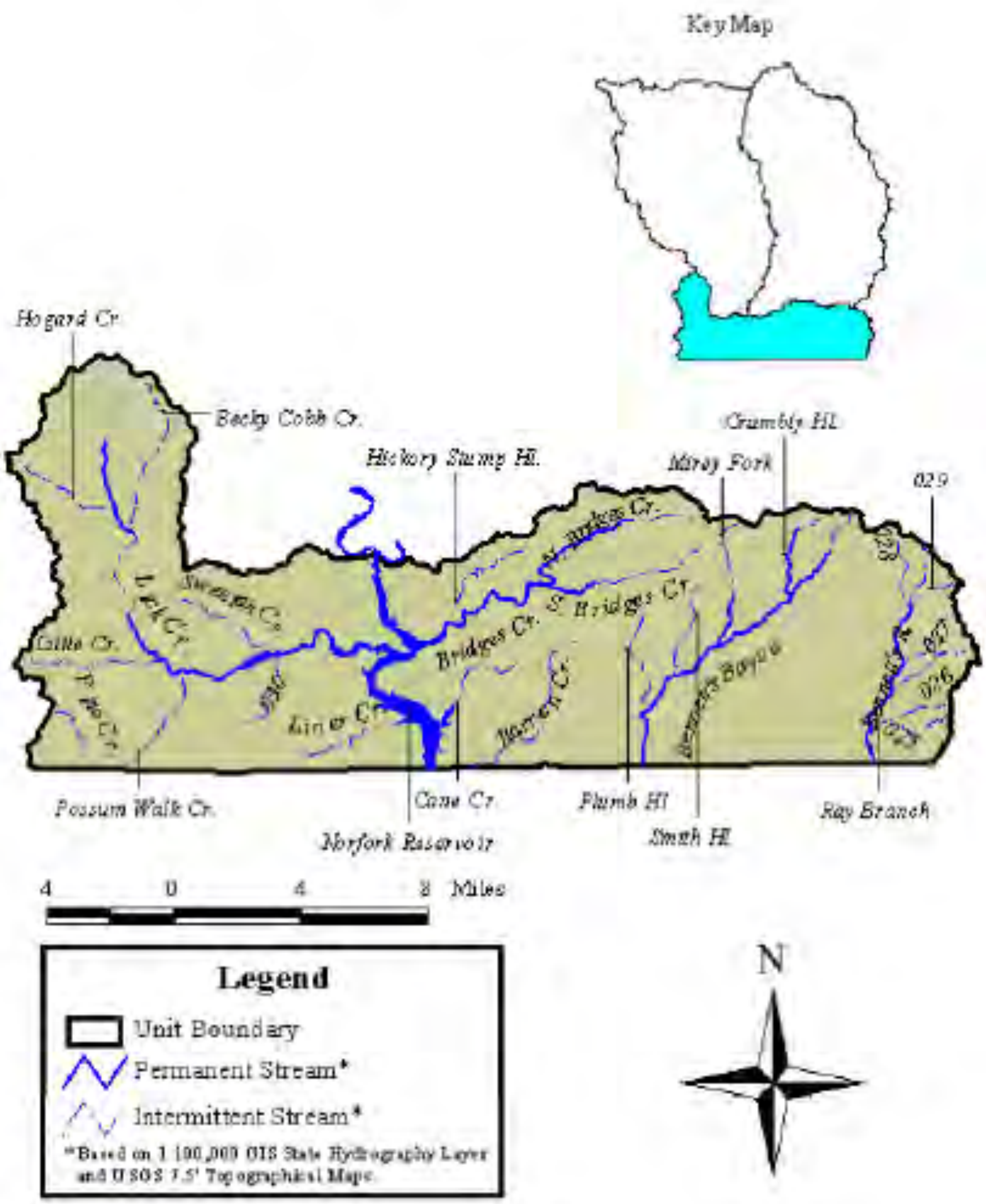


Figure Ge06.

# North Fork Watershed
## Ground Water Transport

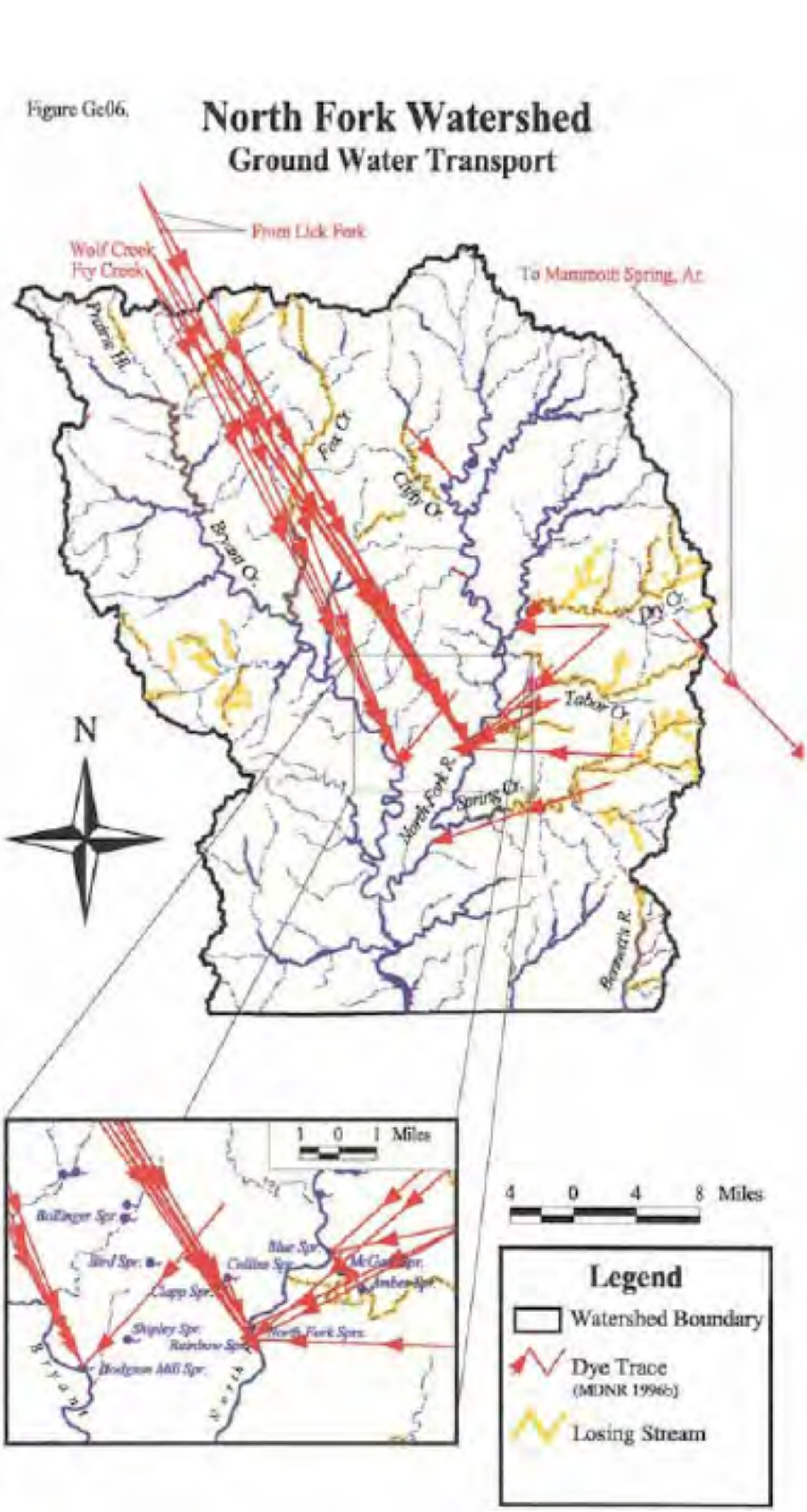


Figure Ge07.

# North Fork Watershed

## Springs

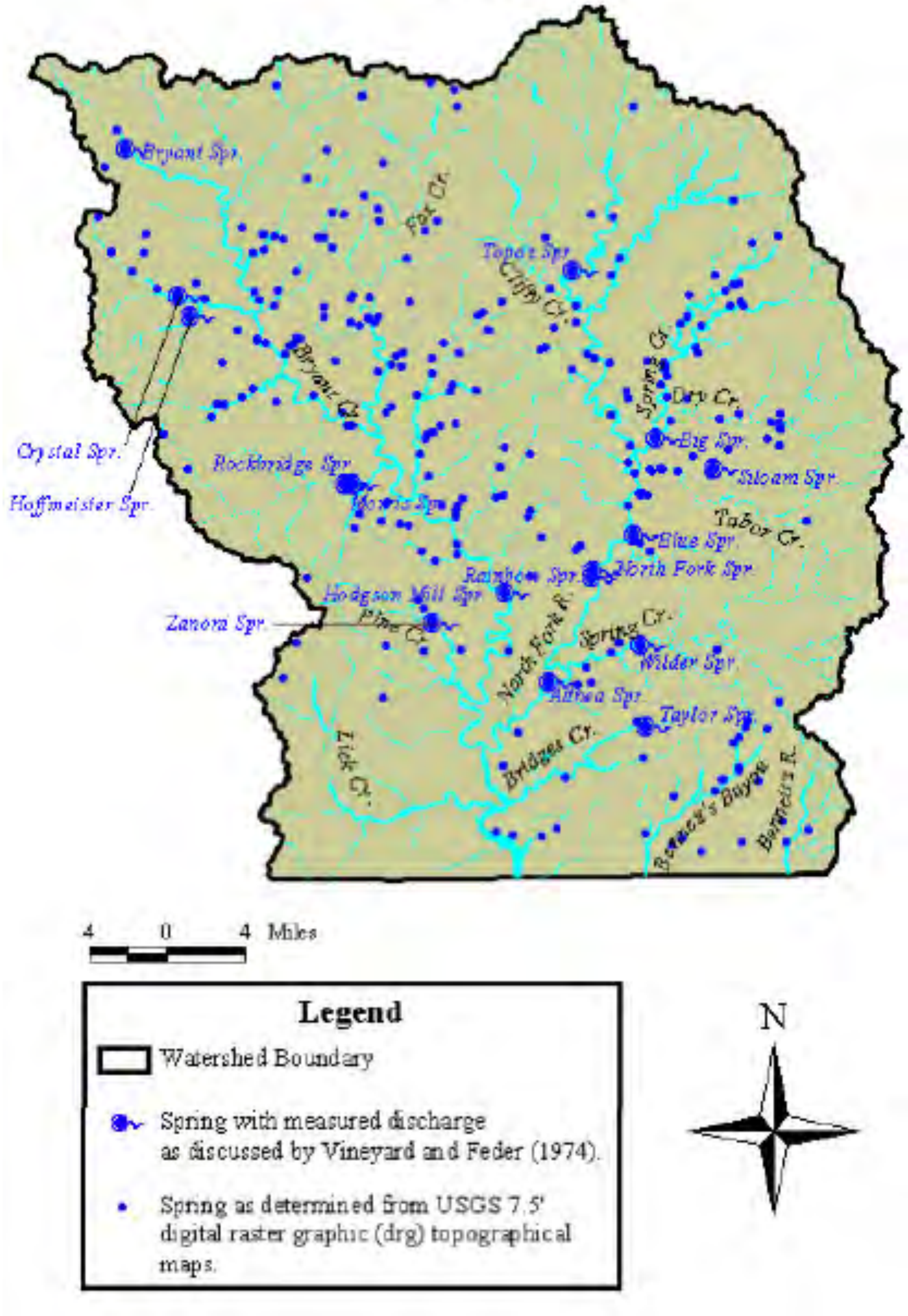


Figure Ge08.

# North Fork Watershed
## Hydrologic Units

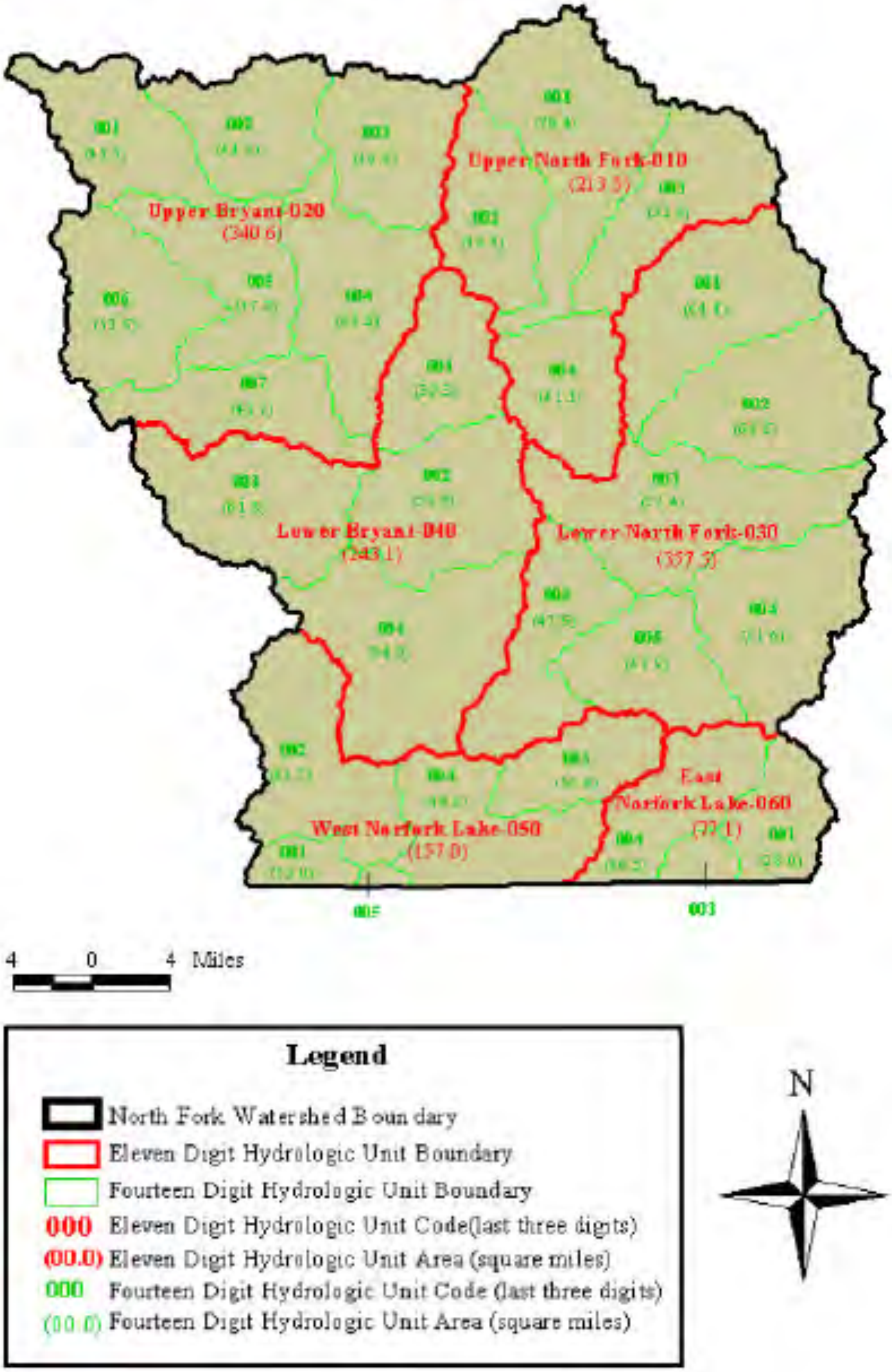
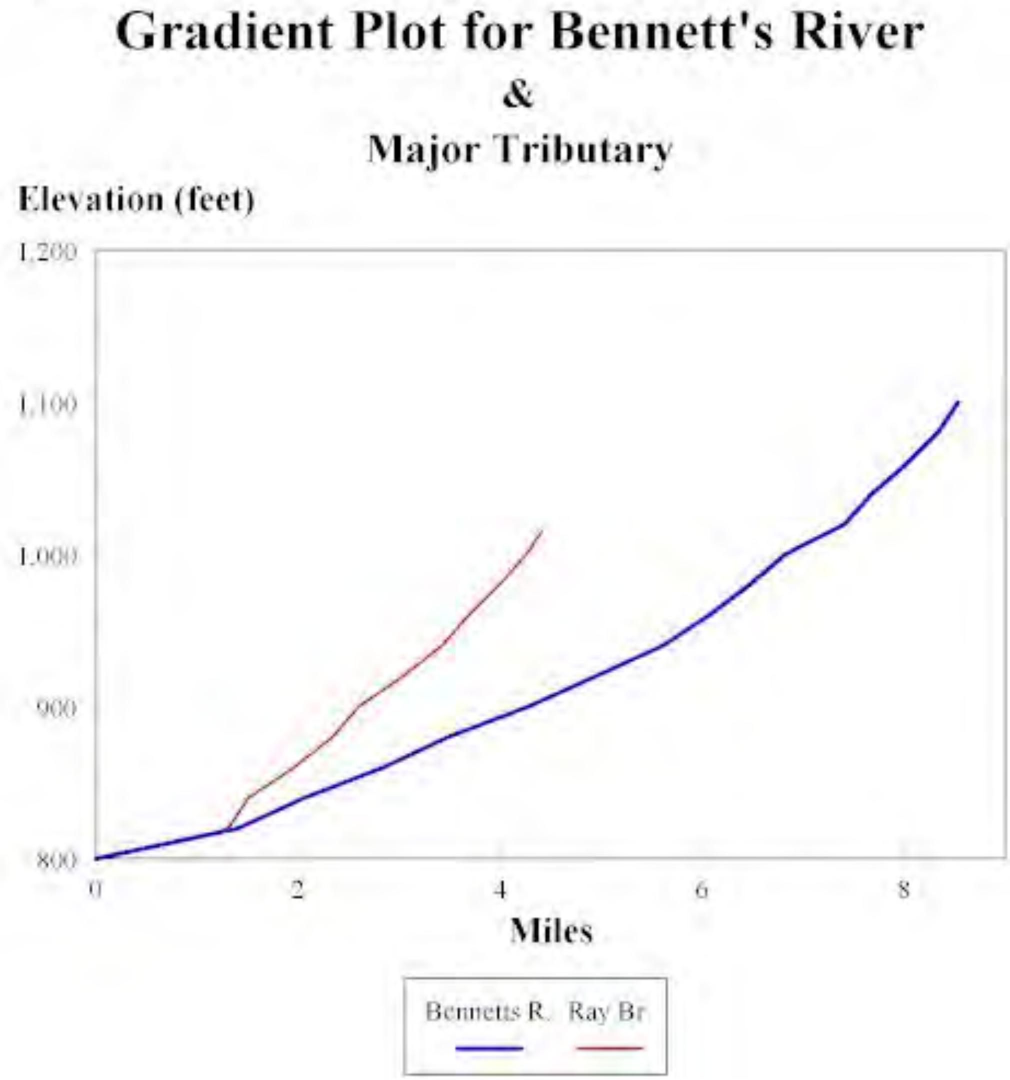


Figure Ge09



Gradient Plot for Bennett's River
&
Major Tributary
Elevation (feet)
1,200
1,100
1,000
900
800
0
2
4
6
8
Miles
Bennetts R.
Ray Br

Figure Ge10.

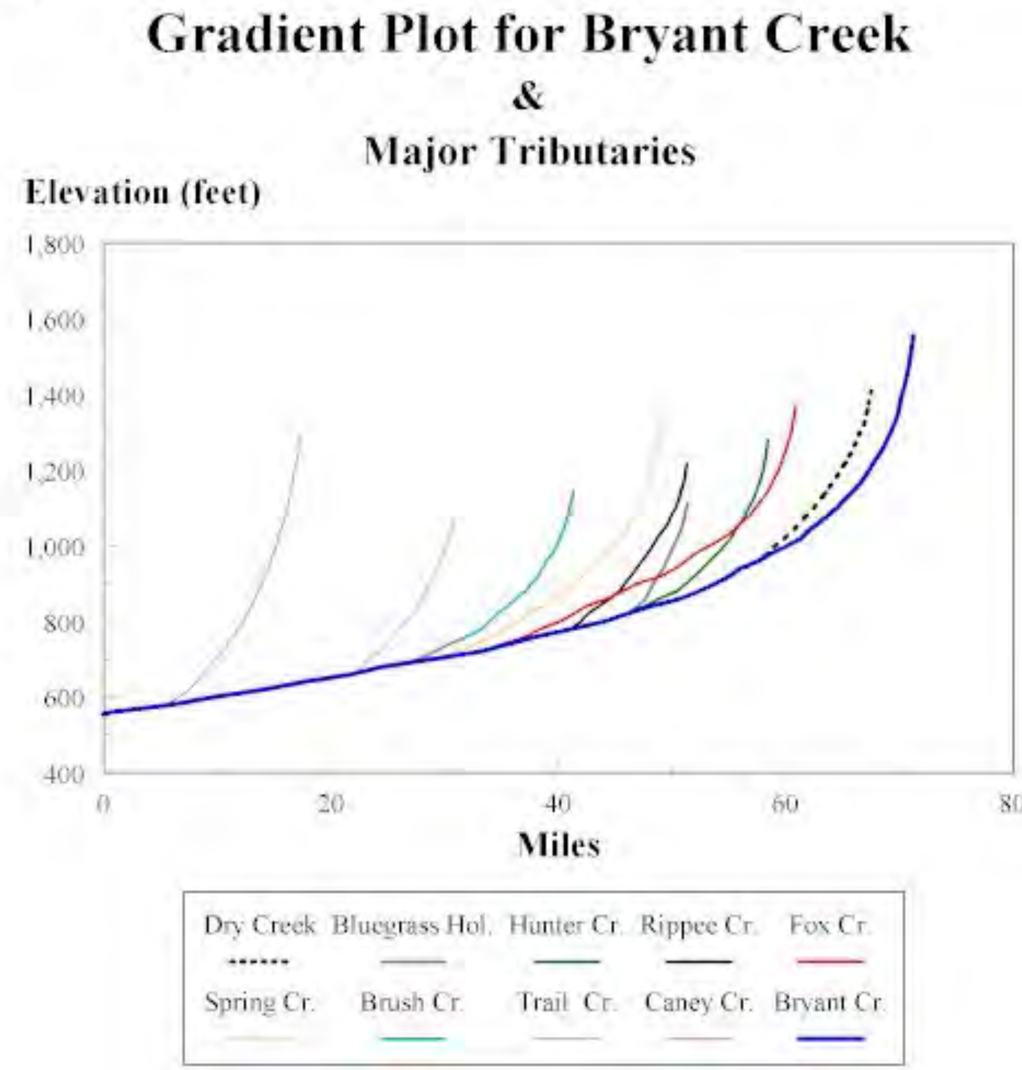
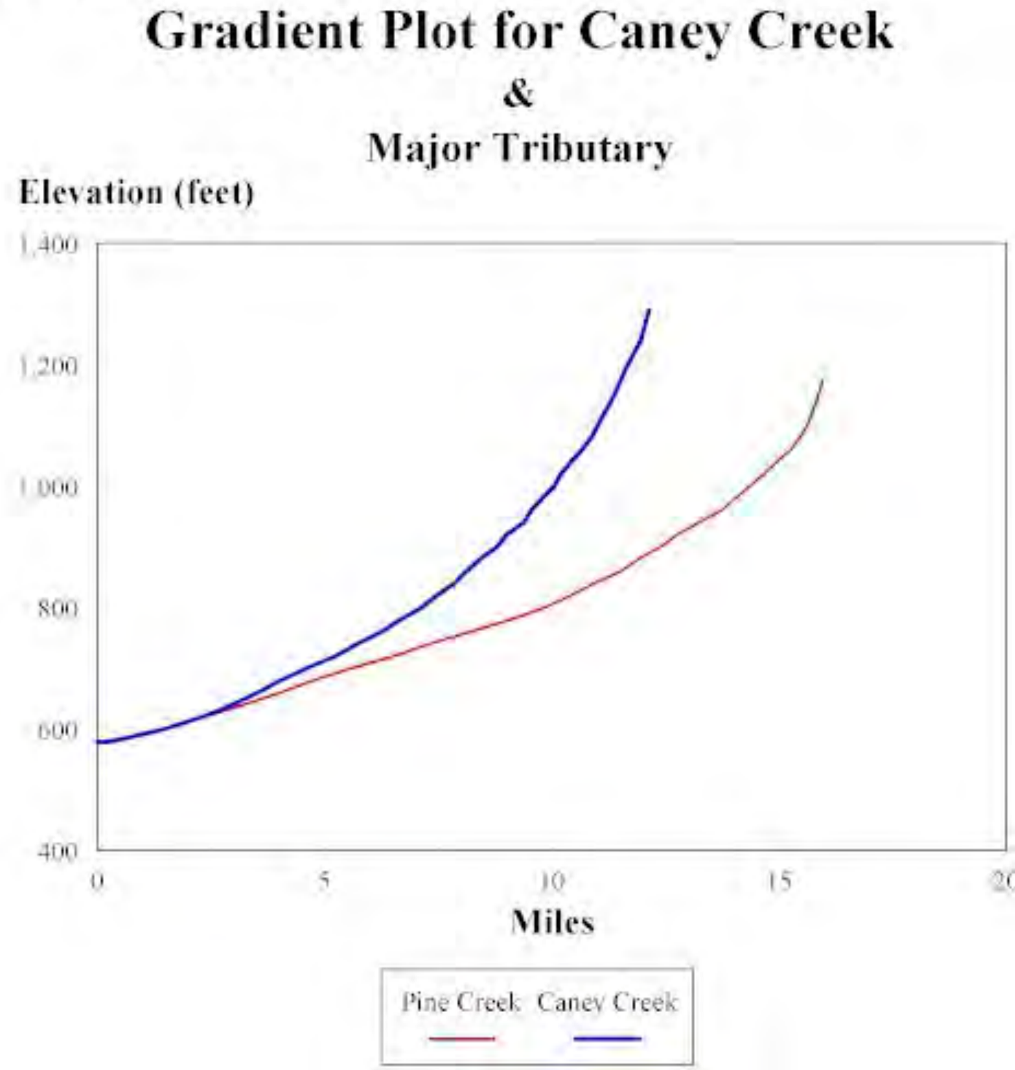

Gradient Plot for Bryant Creek
&
Major Tributaries
Elevation (feet)
1,800
1,600
1,400
1,200
1,000
800
600
400
0
20
40
60
80
Miles
Dry Creek
Bluegrass Hol.
Hunter Cr.
Rippee Cr.
Fox Cr.
Spring Cr.
Brush Cr.
Trail Cr.
Caney Cr.
Bryant Cr.

Figure Ge11



Gradient Plot for Caney Creek
&
Major Tributary
Elevation (feet)
1,400
1,200
1,000
800
600
400
0
5
10
15
20
Miles
Pine Creek
Caney Creek

Figure Ge12.

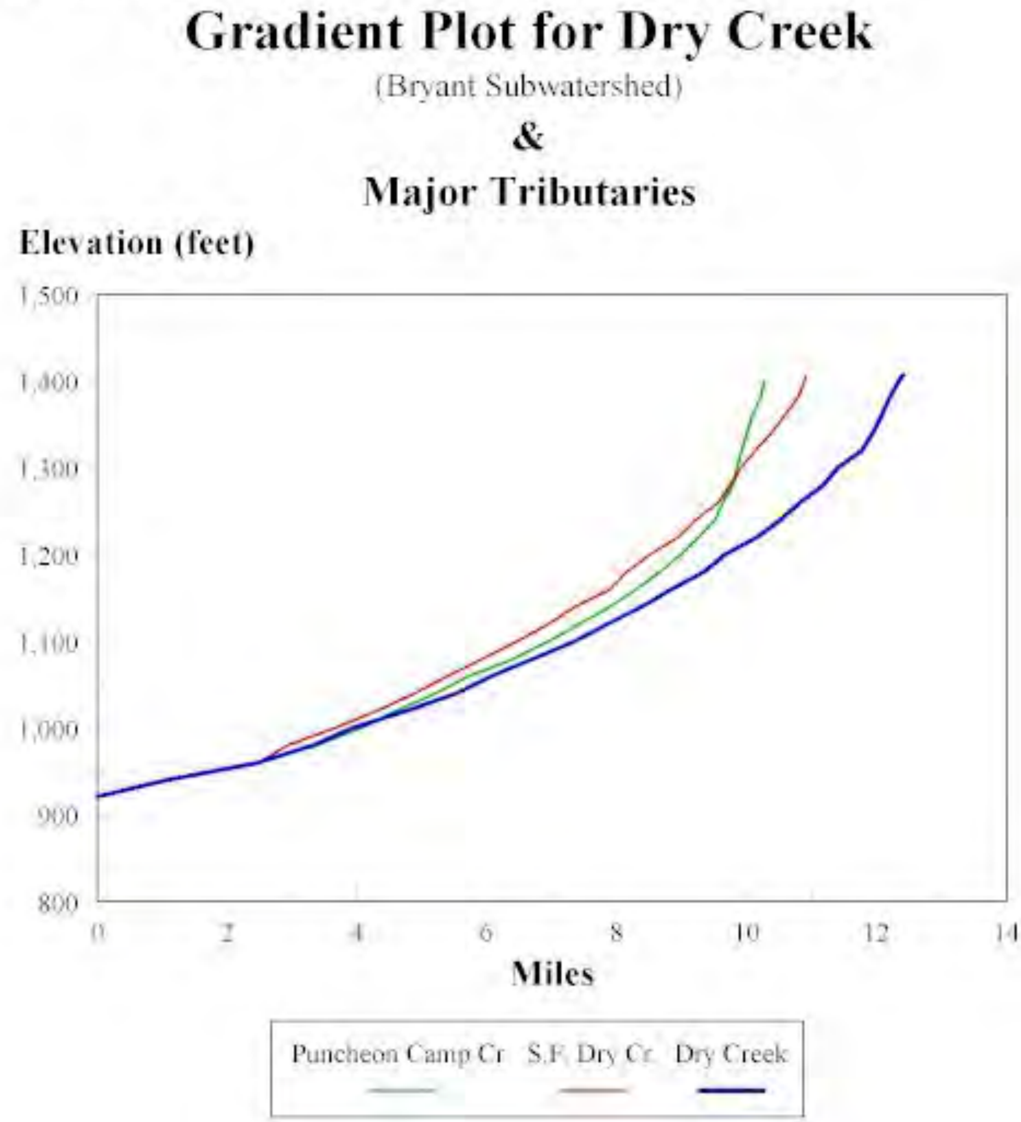

Gradient Plot for Dry Creek
(Bryant Subwatershed)
&
Major Tributaries
Elevation (feet)
1,500
1,400
1,300
1,200
1,100
1,000
900
800
0
2
4
6
8
10
12
14
Miles
Puncheon Camp Cr
S.F. Dry Cr.
Dry Creek

Figure Ge13

# Gradient Plot for Dry Creek

(Spring Creek Subwatershed)

&

Major Tributaries

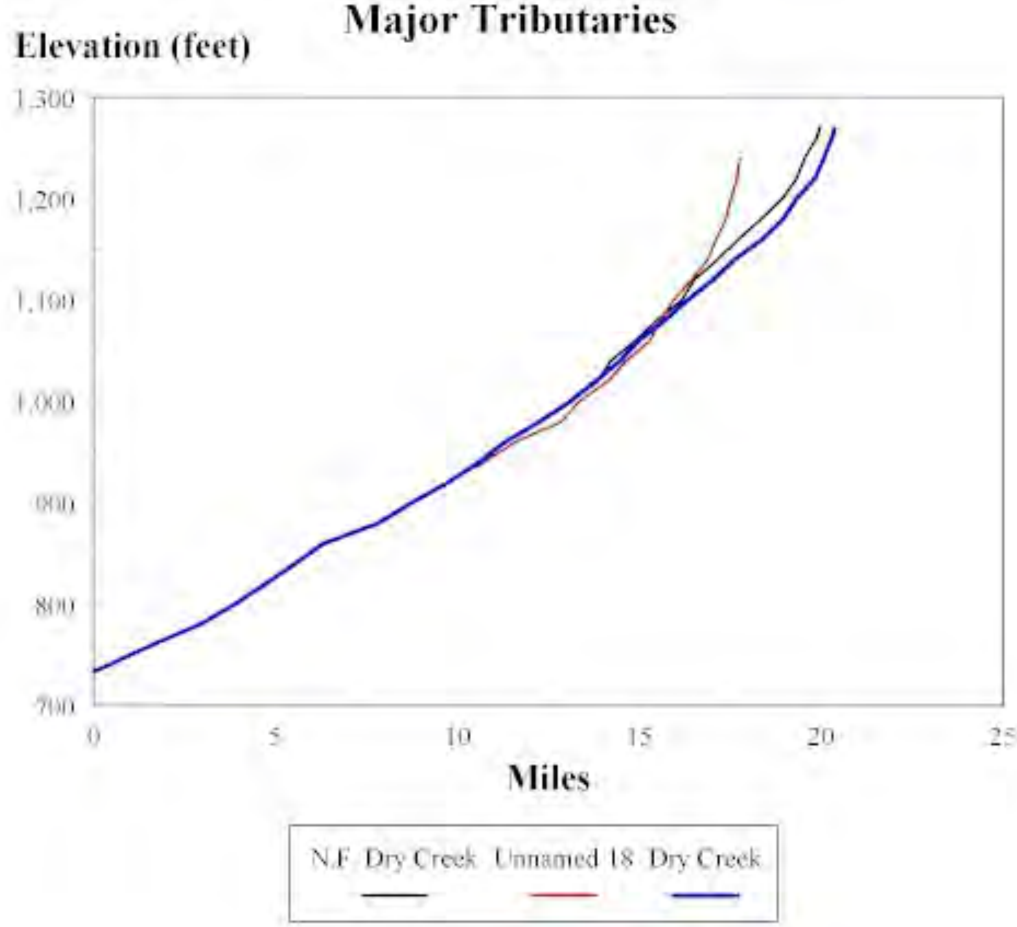


Figure Ge14

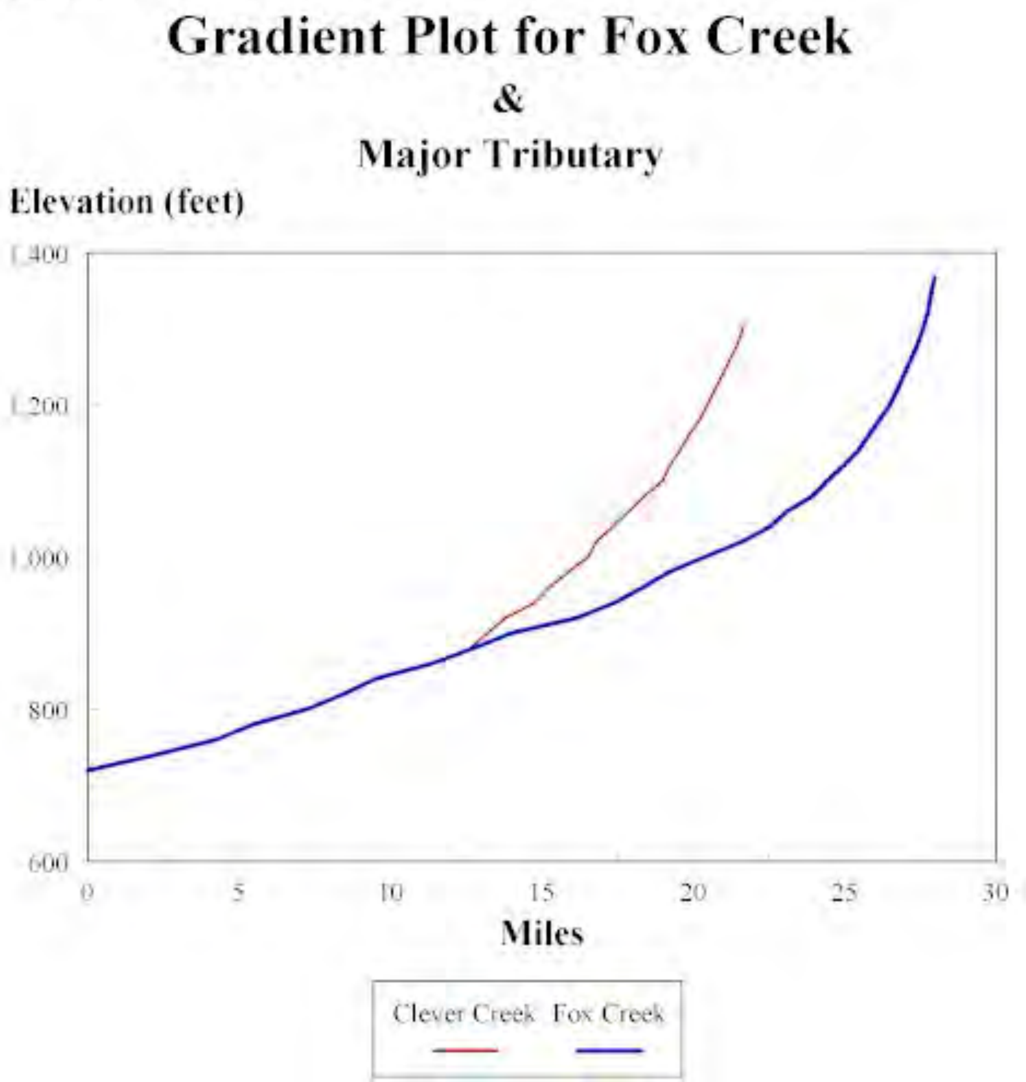

Gradient Plot for Fox Creek
&
Major Tributary
Elevation (feet)
1,400
1,200
1,000
800
600
0
5
10
15
20
25
30
Miles
Clever Creek
Fox Creek

Figure Ge15.

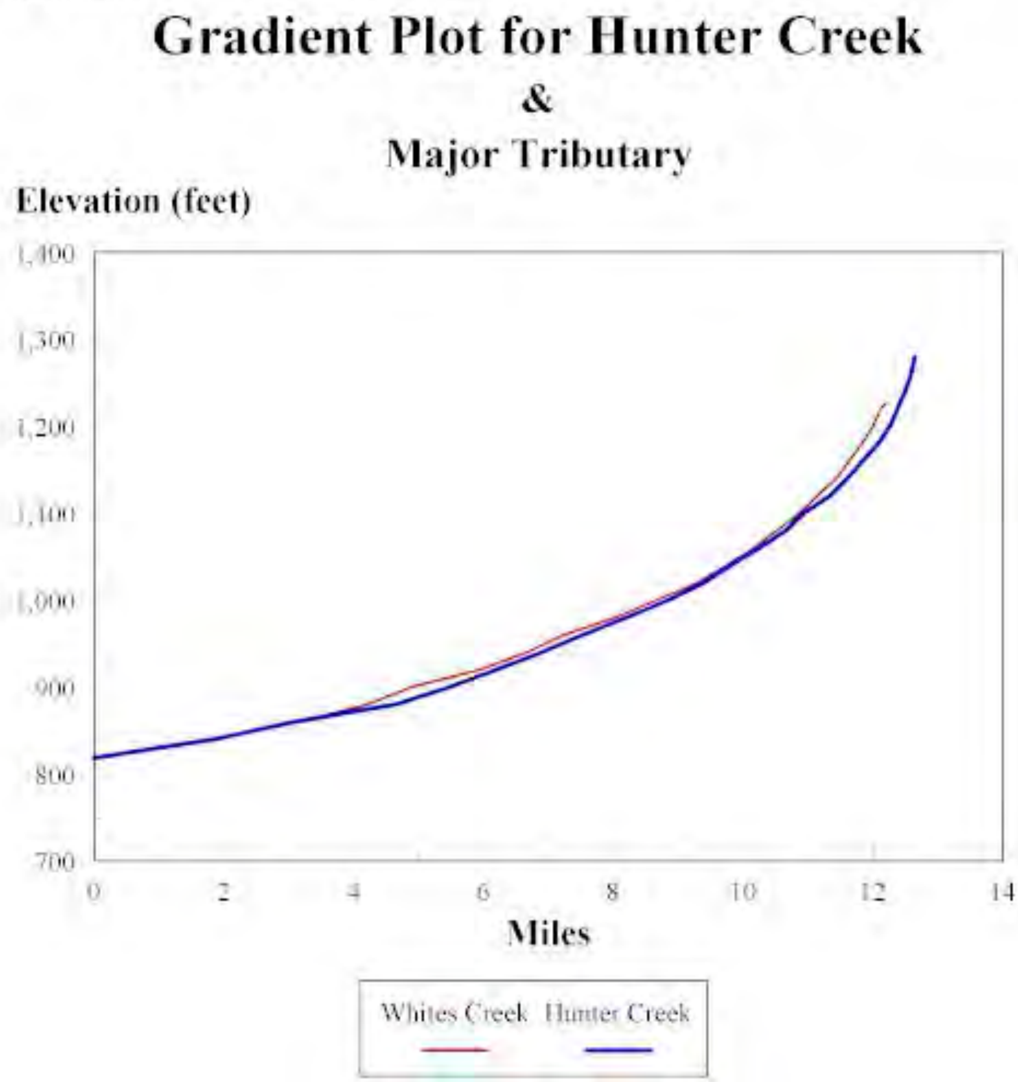

Gradient Plot for Hunter Creek
&
Major Tributary
Elevation (feet)
1,400
1,300
1,200
1,100
1,000
900
800
700
0
2
4
6
8
10
12
14
Miles
Whites Creek
Hunter Creek

Figure Ge16.

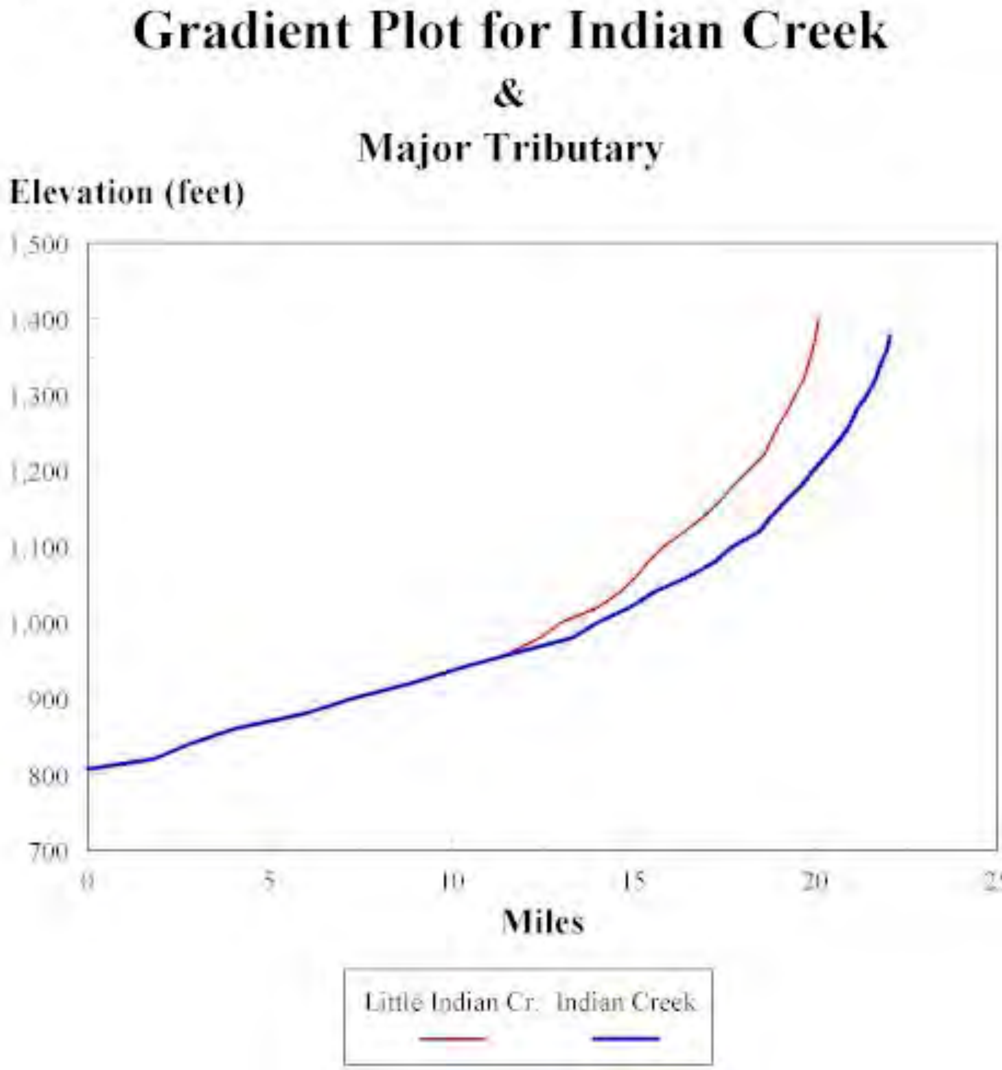

Gradient Plot for Indian Creek
&
Major Tributary
Elevation (feet)
1,500
1,400
1,300
1,200
1,100
1,000
900
800
700
0
5
10
15
20
25
Miles
Little Indian Cr.
Indian Creek

Figure Ge17

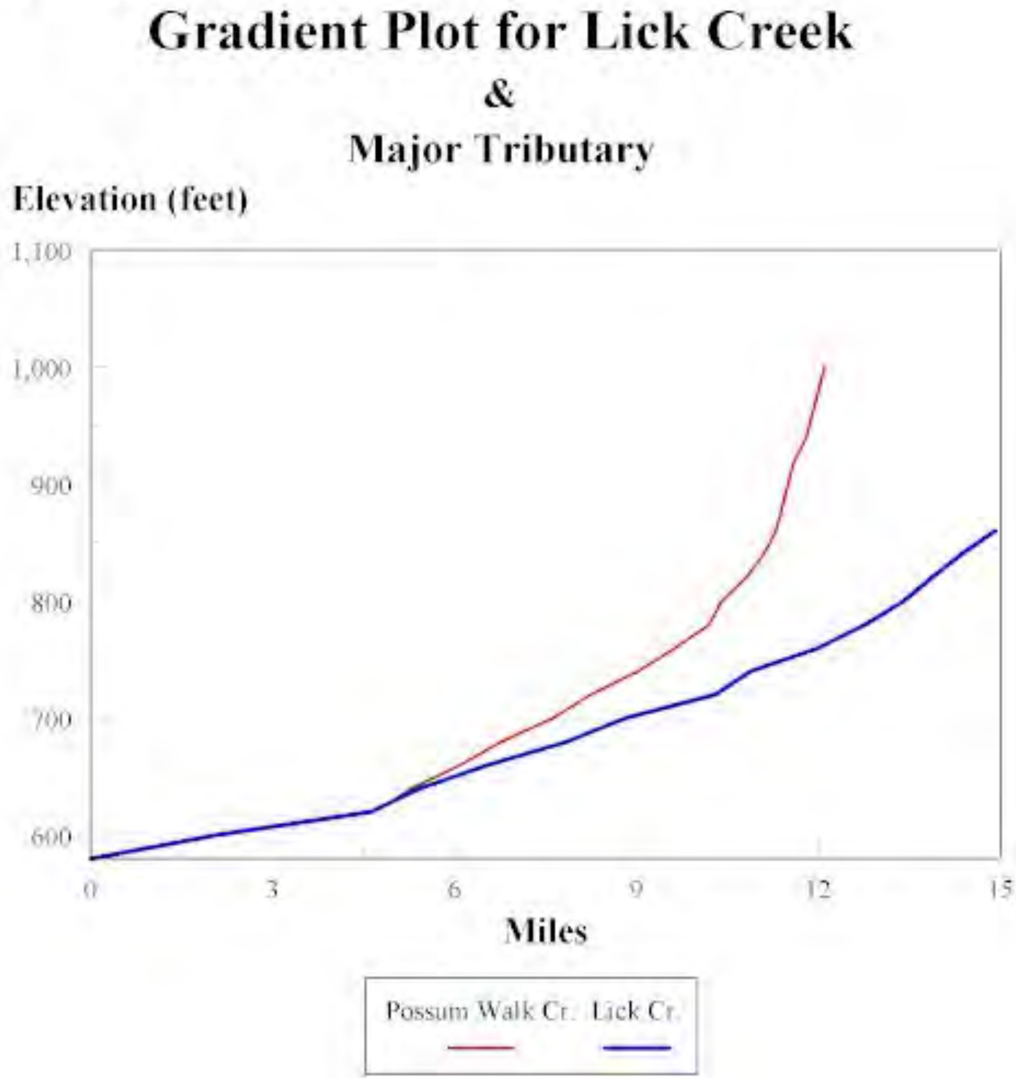

Gradient Plot for Lick Creek
&
Major Tributary
Elevation (feet)
1,100
1,000
900
800
700
600
0
3
6
9
12
15
Miles
Possum Walk Cr.
Lick Cr.

Figure Ge18.

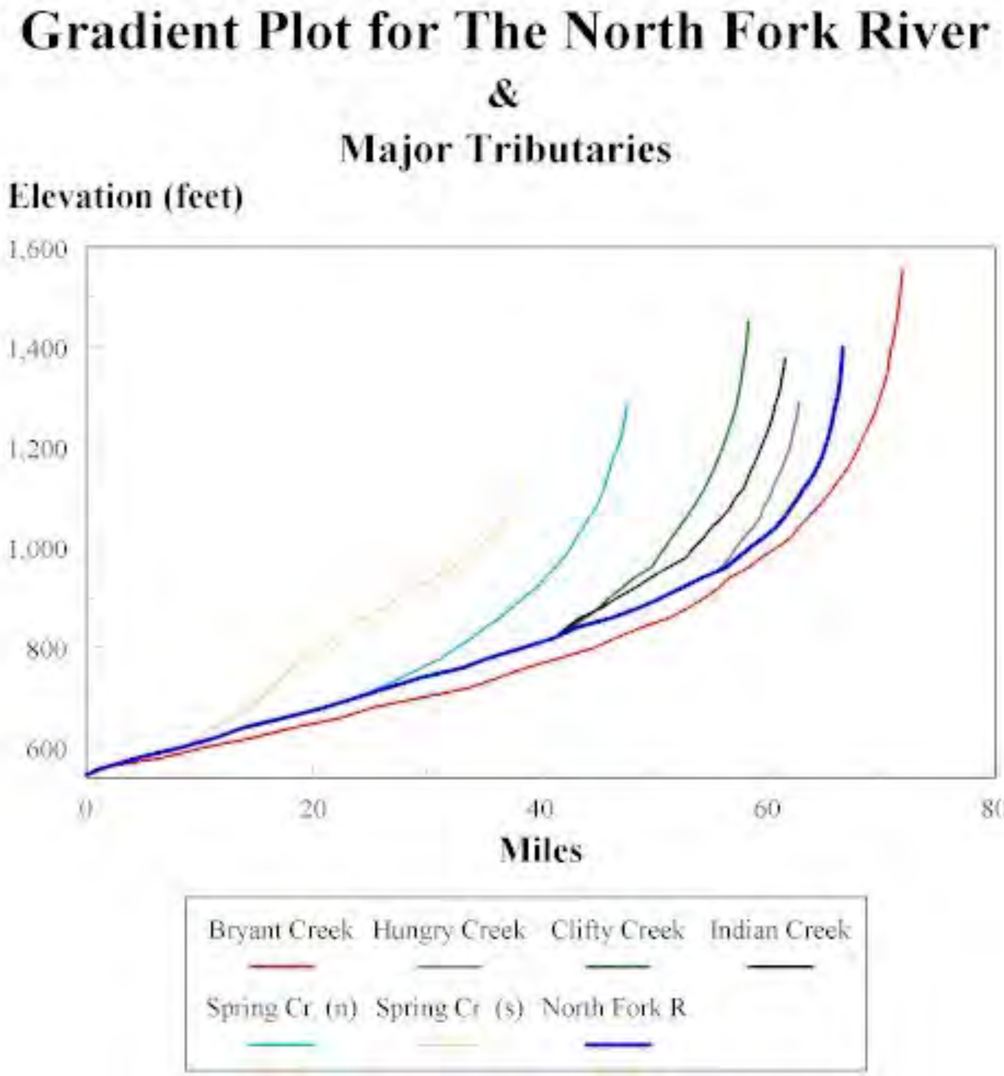

Gradient Plot for The North Fork River
&
Major Tributaries
Elevation (feet)
1,600
1,400
1,200
1,000
800
600
0
20
40
60
80
Miles
Bryant Creek
Hungry Creek
Clifty Creek
Indian Creek
Spring Cr. (n)
Spring Cr. (s)
North Fork R

Figure Ge19.

# Gradient Plot for Spring Creek (North) & Major Tributaries

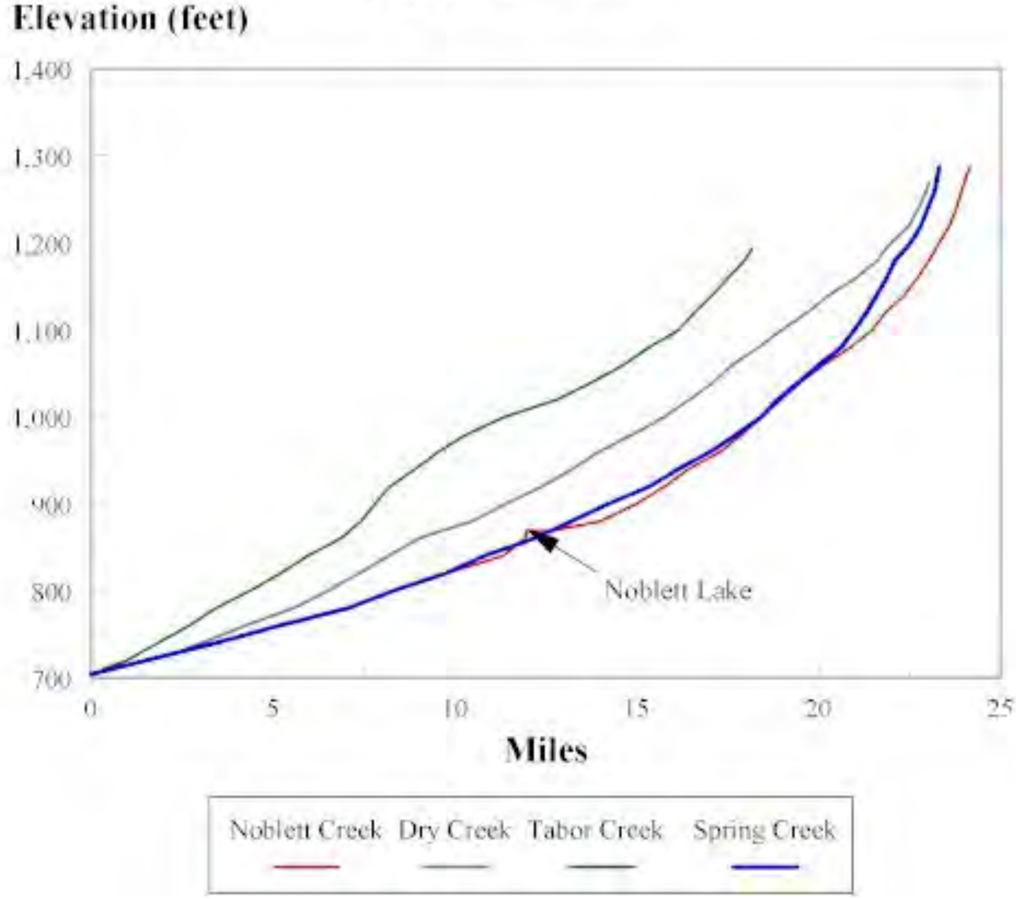
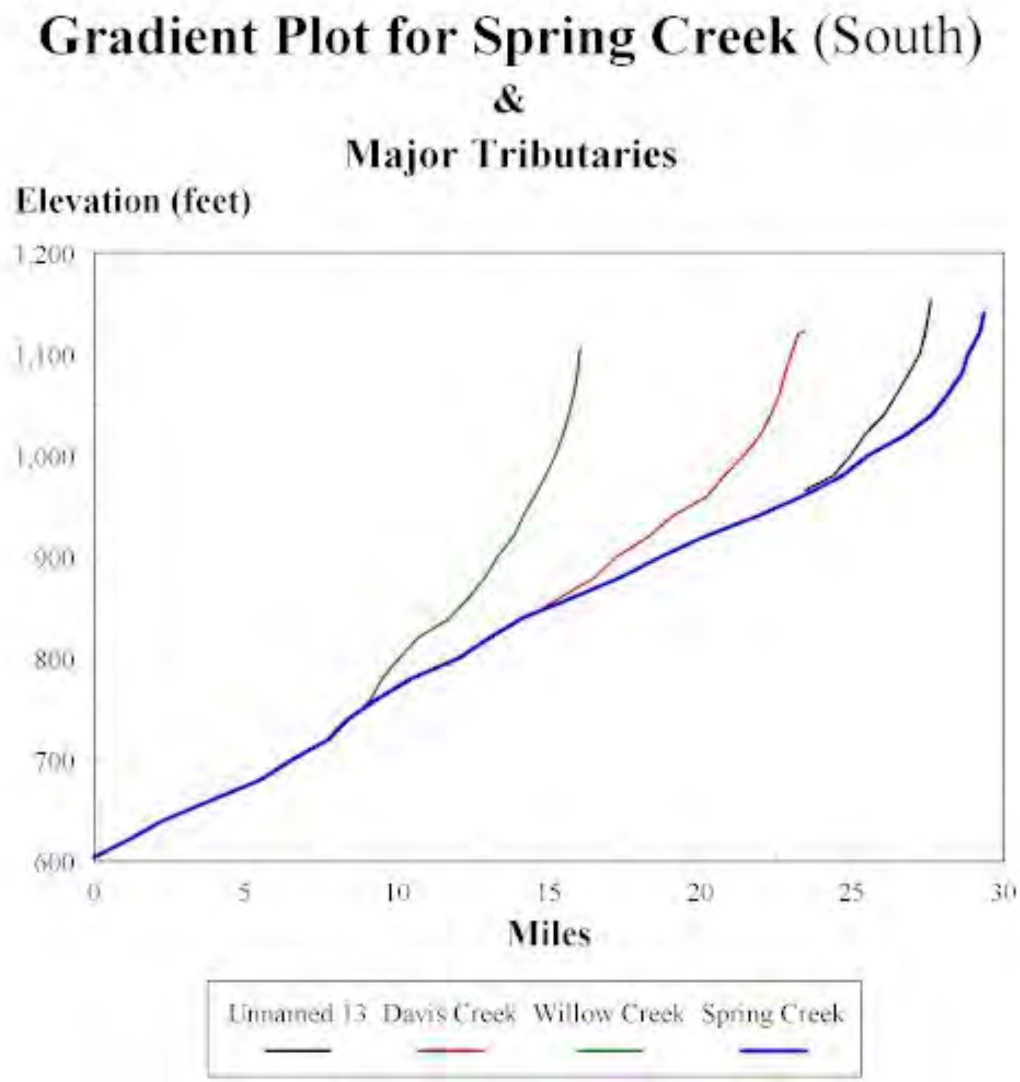


Figure Ge20



Gradient Plot for Spring Creek (South)
&
Major Tributaries
Elevation (feet)
1,200
1,100
1,000
900
800
700
600
0
5
10
15
20
25
30
Miles
Unnamed 13
Davis Creek
Willow Creek
Spring Creek

Table Ge01. Third order and larger streams of the North Fork Watershed.

| Stream Name | Order | USGS 7.5' Quad at Stream Mouth | Name and Order Recieving Stream | Length | |
|---|---|---|---|---|---|
| | | | | P | T |
| **Norfork Lake** | N/A | N/A | N/A | N/A | N/A |
| **Bennett's River** | 5* | Gamaliel, AR | Norfork Lake | 5.9 | 8.5 |
| **Ray Branch** | 4 | Caufield | Bennetts R. 5* | 0 | 3.1 |
| **NFW 025** | 3 | Caufield | Ray Br. 4 | 0 | 2.5 |
| **NFW026** | 3 | Moody | Bennetts R. 4 | 0 | 3.1 |
| **NFW027** | 3 | Moody | Bennetts R. 4 | 0 | 2.5 |
| **NFW028** | 3 | Moody | Bennetts R. 4 | 0 | 2.9 |
| **NFW029** | 3 | Moody | Bennetts R. 4 | 0 | 1.6 |
| **Bennett's Bayou** | 4* | Gamaliel, AR | Norfork Lake | 10.2 | 17.4 |
| **Plumb Hollow** | 3 | Bakersfield | Bennetts Bayou 4 | 0 | 3.6 |
| **Smith Hollow** | 3 | Caufield | Bennetts Bayou 4 | 0 | 3.3 |
| **Mirey Fork** | 3 | Caufield | Bennetts Bayou 4 | 1.9 | 4.5 |
| **Crumby Hollow** | 3 | Caufield | Bennetts Bayou 4 | 2.5 | 3.3 |
| **Barren Creek** | 3 | Gamaliel, AR | Norfork Lake | 0 | 6.6 |
| **Cane Creek** | 3 | Udall | Norfork Lake | 0 | 3.2 |
| **Liner Creek** | 3 | Udall | Norfork Lake | 0 | 1.4 |
| **Lick Creek** | 5 | Udall | Norfork Lake | 12.9 | 14.9 |
| **Sweeten Creek** | 3 | Udall | Lick Cr. 5 | 0 | 4.3 |
| **NFW030** | 3 | Udall | Lick Cr. 5 | 0 | 2.9 |
| **Possum Walk Cr.** | 4 | Gainesville | Lick Cr. 5 | 0 | 7.1 |
| **Pine Creek** | 3* | Midway, AR | Possum Walk Cr. 4 | 0 | 2.5 |
| **Little Creek** | 3 | Gainesville | Lick Cr. 4 | 0 | 4.7 |
| **Becky Cobb Creek** | 3 | Gainesville | Lick Cr. 4 | 0 | 5.4 |
| **Hogard Creek** | 3 | Gainesville | Lick Cr. 4 | 0 | 3.9 |
| **Bridges Creek** | 4 | Udall | Norfork Lake | 4.8 | 4.8 |

| Stream Name | Order | USGS 7.5' Quad at Stream Mouth | Name and Order Recieving Stream | Length | |
|---|---|---|---|---|---|
| | | | | P | T |
| **Hickory Stump Hol** | 3 | Bakersfield | Bridges Cr. 4 | 0 | 4.1 |
| **S. Bridges Creek** | 3 | Bakersfield | Bridges Cr. 4 | 1.8 | 5.4 |
| **N. Bridges Creek** | 3 | Bakersfield | Bridges Cr. 4 | 4.4 | 6.4 |
| **North Fork River** | 7 | Udall | Norfork Lake | 53 | 66.6 |
| **NFW010** | 3 | Udall | North Fork R. 7 | 0 | 2.8 |
| **Smith Hollow** | 3 | Cureall NW | North Fork R. 7 | 0 | 3.4 |
| **Spring Creek** | 5 | Cureall NW | North Fork R. 7 | 5.1 | 29.4 |
| **Sheriff Hollow** | 3 | Cureall NW | Spring Cr. 5 | 0 | 3.9 |
| **Willow Creek** | 4 | Pottersville | Spring Cr. 5 | 0 | 2.5 |
| **Setzer Branch** | 3 | Pottersville | Willow Cr. 4 | 0 | 6.5 |
| **Bridges Branch** | 3 | Pottersville | Willow Cr. 4 | 0 | 3.3 |
| **Joe Pond Hollow** | 3 | Pottersville | Spring Cr. 5 | 0 | 3.4 |
| **Davis Creek** | 4 | Pottersville | Spring Cr. 5 | 0 | 8.8 |
| **Wilson Creek** | 3 | Pottersville | Davis Cr. 4 | 0 | 5.5 |
| **NFW011** | 3 | Pottersville | Davis Cr. 4 | 0 | 3.8 |
| **NFW012** | 3 | South Fork | Davis Cr. 4 | 0 | 2.5 |
| **Tabor Creek** | 3 | Pottersville | Spring Cr. 5 | 0 | 4.2 |
| **Fox Hollow** | 3 | Pottersville | Spring Cr. 5 | 0 | 2.9 |
| **NFW013** | 4 | South Fork | Spring Cr. 5 | 0 | 4.1 |
| **NFW014** | 3 | South Fork | NFW013 | 0 | 2.5 |
| **NFW015** | 3 | South Fork | Spring Cr. 4 | 0 | 1.5 |
| **Ruth Hollow** | 3 | Cureall NW | North Fork R. 7 | 0 | 1.9 |
| **Crooked Branch** | 3 | Cureall NW | North Fork R. 7 | 0 | 6.1 |
| **Mary's Hollow** | 3 | Dora | North Fork R. 7 | 0 | 7.7 |
| **Spring Creek** | 6 | Dora | North Fork R. 7 | 18.1 | 18.1 |
| **Tabor Creek** | 4 | Dora | Spring Cr. 6 | 0 | 17.8 |

| Stream Name | Order | USGS 7.5' Quad at Stream Mouth | Name and Order Recieving Stream | Length | |
|---|---|---|---|---|---|
| | | | | P | T |
| **NFW016** | 3 | Siloam Springs | Tabor Cr. 4 | 0 | 3.6 |
| **NFW017** | 3 | Pomona | Tabor Cr. 4 | 0 | 2.1 |
| **Dry Creek** | 5 | Dora | Spring Cr. 6 | 1.6 | 20.4 |
| **Kenyon Hollow** | 3 | Siloam Springs | Dry Cr. 5 | 0 | 5.1 |
| **NFW018** | 4 | Siloam Springs | Dry Cr. 5 | 0 | 7.3 |
| **NFW019** | 3 | Pomona | NFW018-4 | 0 | 3.6 |
| **NFW020** | 3 | Pomona | NFW019-4 | 0 | 1.7 |
| **North Fork Dry Cr.** | 4 | Pomona | Dry Cr. 4 | 0 | 6.7 |
| **NFW021** | 3 | Pomona | Dry C.r 4 | 0 | 3.3 |
| **NFW022** | 3 | Dyestone Mountain | Spring Cr. 4 | 0 | 4.3 |
| **N. Fork Spring Cr.** | 3 | Dyestone Mountain | Spring Cr. 4 | 0 | 3.6 |
| **S. Fork Spring Cr.** | 3 | Dyestone Mountain | Spring Cr. 4 | 0 | 3.5 |
| **S. Fork Spring Cr.** | 3 | Dyestone Mountain | Spring Cr. 4 | 0 | 3.5 |
| **S. Fork Spring Cr.** | 3 | Dyestone Mountain | Spring Cr. 4 | 0 | 3.5 |
| **Noblett Creek** | 4 | Dyestone Mountain | Spring Cr. 5 | 12.3 | 14.7 |
| **Cord Hollow** | 3 | Dyestone Mountain | Noblett Cr. 4 | 0 | 3.5 |
| **Crooked Creek** | 3 | Dyestone Mountain | Noblett Cr. 4 | 0 | 6.1 |
| **Brushy Creek** | 3 | Dyestone Mountain | Noblett Cr. 4 | 0 | 2.9 |
| **Zach's Branch** | 3 | Dora | North Fork R. 6 | 0 | 4.7 |
| **Robinson Hollow** | 3 | Dora | North Fork R. 6 | 0 | 5.9 |
| **Prarie Hollow** | 3 | Nichols Knob | North Fork R. 6 | 0 | 4.1 |
| **Indian Creek** | 5 | Nichols Knob | North Fork R. 6 | 17.5 | 22.1 |
| **Little Indian Cr.** | 4 | Dyestone Mountain | Indian Cr. 5 | 5.3 | 8.5 |
| **NFW023** | 3 | Cabool SE | Little Indian Cr. 4 | 0 | 5.2 |

| Stream Name | Order | USGS 7.5' Quad at Stream Mouth | Name and Order Recieving Stream | Length | |
|---|---|---|---|---|---|
| | | | | P | T |
| **Middle Indian Cr.** | 3 | Dyestone Mountain | Indian Cr. 4 | 4 | 7.4 |
| **Clifty Creek** | 4 | Nichols Knob | North Fork R. 5 | 2.9 | 16.4 |
| **Jim Coble Hollow** | 3 | Nichols Knob | Clifty Cr. 4 | 0 | 4.5 |
| **Red Bank Creek** | 3 | Vanzant | Clifty Cr. 4 | 0 | 4.8 |
| **East Clifty Creek** | 3 | Mountin Grove S | Clifty Cr. 4 | 0 | 3.7 |
| **Greasy Creek** | 3 | Cabool SW | North Fork R. 5 | 0 | 5.9 |
| **Hungry Creek** | 4 | Cabool SW | North Fork R. 5 | 1.6 | 7 |
| **NFW024** | 3 | Cabool SW | Hungry Cr. 4 | 0 | 3.4 |
| **Little Creek** | 3 | Cabool SW | North Fork R. 4 | 1.3 | 11.3 |
| **Panther Creek** | 3 | Cabool SW | North Fork R. 4 | 0 | 4.9 |
| **Bryant Creek** | 6 | Udall | North Fork R. 7 | 58.3 | 71.2 |
| **Little Pine Creek** | 3 | Udall | Bryant Cr. 6 | 0 | 6.8 |
| **Caney Creek** | 5 | Sycamore | Bryant Cr. 6 | 2.4 | 12.1 |
| **Pine Creek** | 4 | Sycamore | Caney Cr. 5 | 2.9 | 14.3 |
| **Holdman Hollow** | 3 | Sycamore | Pine Cr. 4 | 0 | 2.9 |
| **Wiedensaul Hollow** | 3 | Sycamore | Caney Cr. 4 | 0 | 4.1 |
| **Lottie Hollow** | 3 | Sycamore | Bryant Cr. 6 | 0 | 3.2 |
| **Bollinger Branch** | 3 | Sycamore | Bryant Cr. 6 | 0 | 6 |
| **Hurricane Creek** | 3 | Sycamore | Bryant Cr. 6 | 0 | 4.7 |
| **Trail Creek** | 4 | Sycamore | Bryant Cr. 6 | 0 | 8.6 |
| **Burgess Hollow** | 3 | Gentryville | Trail Cr. 4 | 0 | 6.4 |
| **Brown Hollow** | 3 | Gentryville | Trail Cr. 4 | 0 | 4.1 |
| **Owens Hollow** | 3 | Gentryville | Bryant Cr. 6 | 0 | 3.5 |
| **Dry Creek** | 3 | Gentryville | Bryant Cr. 6 | 0 | 5.1 |
| **Brush Creek** | 4 | Gentryville | Bryant Cr. 6 | 7.2 | 14.6 |

| Stream Name | Order | USGS 7.5' Quad at Stream Mouth | Name and Order Recieving Stream | Length | |
|---|---|---|---|---|---|
| | | | | P | T |
| **Little Brush Creek** | 3 | Gentryville | Brush Cr. 4 | 3 | 6.3 |
| **Pedro Hollow** | 3 | Vanzant | Brush Cr. 4 | 0 | 4 |
| **West Fork** | 3 | Vanzant | Brush Cr. 4 | 0 | 4.2 |
| **Cane Bottom Hol.** | 3 | Gentryville | Bryant Cr. 6 | 0 | 2.5 |
| **Spring Creek** | 4 | Gentryville | Bryant Cr. 6 | 3.8 | 19.1 |
| **Brixey Creek** | 3 | Rockbridge | Spring Cr. 4 | 1.9 | 5.8 |
| **Gardner Hollow** | 3 | Rockbridge | Spring Cr. 4 | 0 | 4.4 |
| **NFW001** | 3 | Rockbridge | Spring Cr. 4 | 0 | 2.9 |
| **Smith Hollow** | 3 | Rockbridge | Spring Cr. 4 | 0 | 6.7 |
| **Nance Creek** | 3 | Rockbridge | Spring Cr. 4 | 0 | 2.6 |
| **Smith Hollow** | 3 | Wasola | Spring Cr. 4 | 0 | 6.7 |
| **Fox Creek** | 5 | Rockbridge | Bryant Cr. 6 | 9.7 | 28 |
| **Coontz Hollow** | 3 | Brushy Knob | Fox Cr. 5 | 0 | 3.7 |
| **Clever Creek** | 4 | Brushy Knob | Fox Cr. 5 | 0 | 9 |
| **Wolfpen Hollow** | 3 | Brushy Knob | Clever Cr. 4 | 0 | 3.3 |
| **Greasy Creek** | 3 | Brushy Knob | Fox Cr. 4 | 0 | 4.4 |
| **NFW002** | 3 | Vanzant | Fox Cr. 4 | 0 | 3.4 |
| **NFW003** | 3 | Mountain Grove S | Fox Cr. 4 | 0 | 4.2 |
| **East Prong** | 3 | Mountain Grove S | Fox Cr. 4 | 1.2 | 4.9 |
| **NFW004** | 3 | Mountain Grove S | Fox Cr. 4 | 0 | 4.4 |
| **Boiler Hollow** | 3 | Rockbridge | Bryant Cr. 6 | 0 | 1.9 |
| **Rippee Creek** | 4 | Rockbridge | Bryant Cr. 6 | 5.3 | 10.2 |
| **Strong Spring Br.** | 3 | Wasola | Rippee Cr. 4 | 0 | 1.8 |
| **Hunter Creek** | 5 | Brushy Knob | Bryant Cr. 6 | 7 | 12.6 |
| **Whites Creek** | 4 | Sweden | Hunter Cr. 5 | 2.8 | 8.6 |
| **Jack's Fork** | 3 | Sweden | Whites Cr. 4 | 0 | 4.6 |

| Stream Name | Order | USGS 7.5' Quad at Stream Mouth | Name and Order Recieving Stream | Length | |
|---|---|---|---|---|---|
| | | | | P | T |
| **NFW005** | 3 | Sweden | Whites Cr. 4 | 0 | 3.3 |
| **Wildcat Creek** | 3 | Sweden | Hunter cr. 4 | 0 | 3.9 |
| **Bluegrass Hollow** | 4 | Brushy knob | Bryant Cr. 5 | 0 | 5.3 |
| **Wilson Hollow** | 3 | Brushy Knob | Bluegrass Hol. 4 | 0 | 2.5 |
| **Tarbutton Creek** | 3 | Sweden | Bryant Cr. 5 | 3 | 4.9 |
| **Camp Creek** | 3 | Sweden | Bryant Cr. 5 | 0 | 2.8 |
| **Bill Mack's Creek** | 3 | Sweden | Bryant Cr. 5 | 0 | 4.6 |
| **Dry Creek** | 5 | Sweden | Bryant Cr. 5 | 0 | 12.4 |
| **S. Fork Dry Creek** | 4 | Mansfield | Dry Cr. 5 | 0 | 8.5 |
| **NFW006** | 3 | Norwood | S. Fork Dry Cr. 4 | 0 | 4.2 |
| **Puncheon Camp Cr.** | 3 | Mansfield | Dry Cr. 5 | 0 | 6.9 |
| **NFW007** | 3 | Mansfield | Puncheon Cmp Cr. 4 | 0 | 2.7 |
| **NFW008** | 3 | Norwood | Dry Cr. 4 | 0 | 3.5 |
| **NFW009** | 3 | Norwood | Dry Cr. 4 | 0 | 2.9 |
| **Prairie Hollow** | 3 | Mansfield | Bryant Cr. 4 | 0 | 8.5 |
| **Panther Hollow** | 3 | Mansfield | Bryant Cr. 4 | 0 | 2.1 |

**P**-Permanent Stream Miles (Based on USGS 7.5' topographical maps)

**T**-Total Stream Miles (Digitized from USGS 7.5' topographical maps for 4th order and larger streams. Determined from 1:100,000 scale GIS hydrography coverage for 3rd order streams.)

Table Ge02. Stream length by order (Strahler) and total length for fifth order (Horton) and larger streams in the North Fork Watershed (Missouri). Note figures are rounded to the nearest tenth, therefore total length may not match sum of miles per order.

| Stream Name | Length for Order (miles) | | | | | | | Total Length |
|---|---|---|---|---|---|---|---|---|
| | 7 | 6 | 5 | 4 | 3 | 2 | 1 | |
| **North Fork R.** | 24.3 | 15.2 | 16.3 | 5.6 | 2.8 | 1.6 | 1.1 | 66.6 |
| **Spring Cr. (South)** | | | 23.8 | 1.8 | 3 | 0.3 | 0.5 | 29.4 |
| **Spring Cr. (North)** | | 2.7 | 6.9 | 10 | 1.5 | 1.3 | 0.9 | 23.3 |
| **Dry Cr. (Spring Cr.)** | | | 10.4 | 2.8 | 3.7 | 2.8 | 0.6 | 20.4 |
| **Indian Cr.** | | | 13.3 | 0.3 | 4.9 | 2.5 | 1 | 22.1 |
| **Bryant Cr.** | | 45.8 | 9.4 | 2.7 | 9.9 | 2.5 | 0.9 | 71.2 |
| **Caney Cr.** | | | 1.6 | 1 | 2.7 | 4.4 | 2.5 | 12.1 |
| **Hunter Cr.** | | | 3.6 | 2.9 | 4.7 | 0.8 | 0.6 | 12.6 |
| **Dry Cr. (Bryant)** | | | 3.3 | 6.1 | 1 | 1.1 | 0.9 | 12.4 |
| **Bennetts R.** | | | 1.3 | 5 | 1.1 | 0.5 | 0.7 | 8.5 |
| **Lick Cr.** | | | 5 | 6.4 | 3.5 | Landers Hol./Finley Hol. | | 14.9 |
| **Fox Cr.** | | | 12.8 | 10 | 3.6 | 0.6 | 0.9 | 28 |
| **Total** | 24.3 | 63.7 | 107.7 | 54.7 | 42.4 | 18.4 | 10.6 | 321.5 |

Table Ge03. North Fork Watershed stream reaches designated as losing in Table J Rules of Department of Natural Resources Division 20-Clean Water Commission Chapter 7-Water Quality. Code of State Regulations (MDNR 1996a).

| | | | |
|---|---|---|---|
| **Bryant Cr.** | 8 | se,sw,ne,23,27n,15w | sw,sw,sw,21,26n,14w |
| **Browning Hl.** | 2.5 | sw,ne,nw,27,25n,14w | ne,ne,se,01,24n,14w |
| **Clifty Cr.** | 5.5 | nw,ne,se,28,27n,12w | se,ne,se,14,26n,12w |
| **Brush Cr.** | 4 | ne,nw,se,21,26n,12w | nw,nw,se,36,26n,13w |
| **Smith Hl.** | 4 | se,nw,ne,31,25n,14w | se,ne,se,02,24n,14w |
| **Spring Cr.** | 12 | ne,sw,sw,22,25n,15w | se,sw,nw,05,24n,13w |
| **Horton Hl.** | 2 | nw,sw,ne,05,25n,10w | sw,ne,sw,18,25n,10w |
| **Moss Hl.** | 4 | ne,se,nw,34,26n,10w | sw,se,se,18,25n,10w |
| **Crooked Br.** | 5 | nw,sw,se,21,24n,10w | se,nw,se,22,24n,11w |
| **Spring Cr.** | 10.5 | nw,nw,nw,06,23n,09w | sw,sw,sw,15,23n,11w |
| **Tabor Cr.** | 5 | nw,se,sw,19,24n,09w | se,sw,sw,34,24n,10w |
| **Tabor Cr.** | 10 | se,ne,nw,34,25n,09w | se,ne,sw,35,25n,11w |
| **Trib. To Tabor Cr.** | 2 | nw,se,ne,35,25n,10w | ne,nw,sw,11,24n,10w |
| **Davis Cr.** | 2 | ne,ne,sw,19,23n,09w | ne,nw,sw,14,23n,10w |
| **Kenyon Hl.** | 2.5 | sw,se,nw,02,25n,10w | ne,ne,ne,21,25n,10w |
| **Spring Cr.** | 5 | nw,23,24n,09w | nw,nw,nw,06,23n,09w |
| **Trib. To Spring Cr.** | 4 | sw,se,nw,02,23n,09w | sw,nw,sw,32,24n,09w |
| **Bennett’s R.** | 6 | ne,sw,01,22n,10w | ne,nw,ne,02,21n,10w |
| **Ray Br.** | 2.5 | ne,sw,sw,32,22n,09w | se,sw,ne,02,21n,10w |
| **N. Fk. Dry Cr.** | 3.5 | ne,ne,ne,30,26n,09w | nw,nw,nw,18,25n,09w |
| **Dry Cr.** | 6 | nw,ne,se,20,26n,09w | nw,nw,nw,18,25n,09w |
| **Dry Cr.** | 8 | nw,nw,nw,18,25n,09w | sw,se,sw,23,25n,11w |
| **Trib. To Dry Dr.** | 7 | nw,ne,sw,14,25n,09w | sw,ne,nw,23,25n,10w |
| **Unnamed Trib.** | 2.5 | se,nw,se,32,24n,14w | nw,nw,ne,35,24n,15w |
| **South Fork** | 5.5 | ne,sw,nw,28,24n,14w | sw,nw,se,33,24n,15w |

| Stream | Miles | From | To |
|---|---|---|---|
| **Smith Hl.** | 2 | ne,nw,sw,18,24n,14w | ne,ne,ne,17,24n,14w |
| **Gardner Hl.** | 4 | nw,sw,sw,24,24n,14w | ne,ne,se,01,24n,14w |
| **Unnamed Trib.** | 3 | se,sw,se,18,28n,13w | nw,nw,ne,05,28n,13w |
| **Fox Cr.** | 4 | nw,ne,ne,30,28n,13w | sw,ne,ne,09,27n,13w |
| **Fox. Cr.** | 20 | ne,ne,sw,20,28n,13w | se,ne,ne,29,25n,13w |
| **Dry Cr.** | 7.5 | sw,ne,nw,24,28n,14w | se,sw,sw,17,27n,14w |
| **Prarie Hl.** | 3 | se,sw,sw,28,28n,15w | sw,sw,se,03,27n,15w |
| **Prarie Hl.** | 2 | sw,nw,sw,28,28n,15w | ne,se,sw,03,27n,15w |
| **Fry Cr./Wolf Cr.** | 3 | nw,sw,sw,11,28n,15w | sw,nw,se,25,29n,15w |
| **Total** | 177.5 | | |

**Note:** This table is not a final authority.

Table Ge04. Location and average discharge of selected springs in the North Fork Watershed (Vineyard and Feder 1974).

| Spring Name | County | USGS 7.5' Quadrangle | FlowRate (cfs) | Date |
|---|---|---|---|---|
| **Althea** | Ozark | Cureall NW | 18.8 | 1926-1964 |
| **Big** | Douglas | Dora | 13.2 | 8/28/64 |
| **Blue** | Ozark | Dora | 16.1 | Nov-67 |
| **Bryant** | Douglas | Mansfield | 0.57 | 8/19/36 |
| **Crystal** | Douglas | Sweden | 11.6 | 12/8/64 |
| **Hoffmeister** | Douglas | Sweden | 2 | 10/19/64 |
| **Rainbow** | Ozark | Cureall NW | 127 | 1919-66 |
| **Hodgson Mill** | Ozark | Sycamore | 36.4 | 1926-1966 |
| **Morris** | Ozark | Rockbridge | 3.24 | 11/15/65 |
| **North Fork** | Ozark | Cureall NW | 68.4 | 10/6/66 |
| **Rockbridge** | Ozark | Rockbridge | 21.9 | 12/8/64 |
| **Siloam** | Howell | Siloam Springs | 0.01 | 1892 |
| **Taylor** | Ozark | | 0.09 | 9/6/25 |
| **Topaz** | Douglas | Nichols Knob | 3.66 | 10/21/64 |
| **Wilder** | Ozark | Cureall NW | 8.51 | 11/6/64 |
| **Zanoni** | Ozark | Sycamore | 0.77 | 12/4/64 |

Table Ge05. Average gradient at order (Strahler) and overall average gradient for fifth order (Horton) and larger streams in the North Fork Watershed (Missouri).

| Stream Name | Gradient At Order (ft/mi) | | | | | | | Average Gradient ft/mi |
|---|---|---|---|---|---|---|---|---|
| | 7 | 6 | 5 | 4 | 3 | 2 | 1 | |
| **North Fork R.** | 6.6 | 6.7 | 9.2 | 18.2 | 32.9 | 67.5 | 151 | 12.8 |
| **Spring Cr. (South)** | | | 15.2 | 19.2 | 25.5 | 80.6 | 76 | 18.3 |
| **Spring Cr. (North)** | | 10.7 | 11.8 | 22.9 | 39.9 | 68.7 | 97.5 | 25 |
| **Dry Cr. (Spring Cr.)** | | | 19.3 | 24.1 | 30.6 | 35.7 | 82.5 | 26.3 |
| **Indian Cr.** | | | 12.9 | 30 | 28.1 | 55.5 | 106.4 | 25.9 |
| **Bryant Cr.** | 5.9 | | 11 | 16.1 | 25.9 | 74.7 | 161.4 | 14.1 |
| **Caney Cr.** | | | 15.3 | 26 | 34.7 | 56.9 | 128.9 | 58.6 |
| **Hunter Cr.** | | | 13.7 | 21.8 | 39.4 | 75.9 | 174.6 | 36.6 |
| **Dry Cr. (Bryant)** | | | 17.5 | 33.7 | 51 | 66 | 108.5 | 39.2 |
| **Bennett's R.** | | | 15.1 | 30.5 | 43 | 64 | 71.8 | 35.2 |
| **Lick Cr.** | | | 10 | 19.4 | 30 | Landers Hol./ Finley Hol. | | 18.8 |
| **Fox Cr.** | 12.7 | | | 16.8 | 39.1 | 96.6 | 129.1 | 23.2 |

# Land Use

## Historical Land Cover/Land Use

Henry Rowe Schoolcraft provides, perhaps, the best early (1821) account of what types of land cover existed within the North Fork Watershed. This is due, in part, to the fact that he and his companion, Levi Pettibone, traveled nearly the entire length of the North Fork River in 1818. Schoolcraft (1821) described the upper portion of the river as being " wholly composed of springs which gush at almost every step from its calcareous banks" and the water as "very pure, cold, and transparent". He mentions "rich bottom lands, covered with elm, beech, oak, maple, sycamore, and ash". He continues to describe bottom lands covered with "luxuriant growth of forest-timber, shrubs, vines, cane, and greenbriar, often so matted and interwoven together, that our progress is not only retarded, but attended with great fatigue". Schoolcraft and his companion, fatigued by the impeded progress in the valley of the North Fork River, moved to the uplands between the North Fork and Bryant Creek, the largest tributary in the watershed. Schoolcraft described this area as "an open barren, with very little timber, or under-brush, and generally level". The broader, more gently sloping uplands are believed to have been composed of open woodlands with occasional prairie and savanna openings with post oak and black oak being the principal tree species (MDC 1997). The land cover of the more dissected landscape nearer the North Fork River and Bryant Creek are believed to have been primarily composed of oak and oak-pine forest with a mixture of hardwoods in the bottoms. Two "pineries" are known to have existed within the North Fork Watershed area in the mid-1800s which encompassed approximately 220 square miles (Smith 1990).

The Ozarks are believed to have first been explored approximately 14,000 years ago by semi nomadic Native American tribes which subsisted as hunters and foragers (Rafferty 1980, Jacobson and Primm 1994). Approximately 1000 B.C., tribes on the fringes of the Ozarks became less nomadic, existing in more permanent villages and incorporating agricultural practices as a means of subsistence. Tribes in the Ozarks interior did not begin adopting these practices until A.D. 900. By A.D. 1500 this culture had disappeared as large agricultural base villages began to grow along the eastern fringe of the Ozarks and the Mississippi River. During this period the interior of the Ozarks was used primarily as a seasonal hunting ground as well as a source for flint and chalcedony for making tools. It is believed that a climatic shift to cooler, drier summers and the resulting failure of maize crops on which early agriculture was based, may have caused an abrupt abandonment of the larger villages. Remnants of these villages and tribes reassembled to form the Osage Tribe which existed throughout much of the Ozarks and was present as European settlement of the area began to occur in the late 1700s and early 1800s (Jacobson and Primm 1994). Native American use of fire, as well as naturally occurring incidences of fire (i.e. lightening strikes), are believed to have been a large determining factor in the types of vegetation found by Schoolcraft and others as exploration of the Ozarks interior began to occur after the Louisiana Purchase of 1803. Native Americans are believed to have set fires for many reasons from harassment of enemies to aiding in hunting. These fires stimulated warm-season grasses such as bluestem and eliminated woody undergrowth thus creating open woodlands or savannas.

European settlement of the Ozark fringe began in the early 1700's under French and, later, Spanish political control. After the Louisiana Purchase of 1803, American settlers began settling the same areas earlier occupied by the Spanish and French. The Osage, in treaty with the federal government, relinquished claims to much of the Ozarks interior in 1808. However, the Osage refused to relinquish their hunting rights in this area (Rafferty 1980). Settlement of the Ozarks interior increased after the war of 1812 (Jacobson and Primm 1994). However, the region remained sparsely settled until the late 1800's. Many of the early settlers came from states such as Indiana, Illinois, Kentucky, Virginia, and Tennessee (Rafferty 1983). Most of these states were previously considered the frontier prior to the Louisiana Purchase. Many of these settlers brought along skills they had learned for survival in frontier territory.

Early settlers subsisted by hunting and fishing as well as maintaining gardens in the small bottomland areas which they cleared. In addition, early settlers raised livestock which grazed on the open range of the slopes and uplands in the summer. In the winter, livestock were fed from forage crops cultivated and harvested from the bottom lands (Jacobson and Primm 1994). The annual practice of burning was continued by early settlers in order to enhance the livestock forage of the uplands. In addition to the influx of settlers of European origin which occurred after the war of 1812, Native American tribes such as the Cherokee, Shawnee, and Delaware which had been displaced from the East began moving through the region (Piland 1991). As the population of the area increased, more settlers were forced to settle the uplands (Smith 1990). Fenced pasture began to replace the practice of open range. These two factors reduced the use of fire on the uplands thus decreasing the grassland and savanna type land cover (Smith 1990; Jacobson and Primm 1994). This region remained sparsely settled until the late 1800's, when the economic values of the vast timber resources were discovered.

The distribution of the first extensive commercial timber cutting in the Ozarks was limited by the distribution of shortleaf pine and transportation routes provided by rivers and railroads (Jacobson and Primm 1994). The timber industry was an important component in the economy of small communities in the North Fork Watershed, although probably not on as large a scale as areas of the Eastern Ozarks such as the Current and Eleven Point Watersheds. Large areas of pine are reported to have existed within the watershed. Geologist B.F. Shumard told of many sawmills in the area in 1853-54. These mills produced lumber which was then hauled by ox team to growing communities such as Springfield, Bolivar, and Linn Creek (Robins 1991a). Timber harvest estimates in Douglas County from around the turn of the century indicate that average annual timber product shipments were approximately 3,000 railroad ties, 4,800 fence and mine posts, 1,200,000 board feet of hardwood lumber, and 680 pieces of piling (Williams 1904). The pine forest during this time was being harvested at a rate of "2,500,000 feet annually" (Williams 1904).

As the logging industry began to decline in the area, residents turned increasingly toward farming as a means of survival. In 1904, the counties of Howell and Douglas had approximately 154,000 acres (26%) and 126,885 acres (25%) under cultivation respectively (Williams 1904). Williams (1904) states that in 1904 Ozark County had 79,085 acres (16%) of "improved farmlands". Estimates of 1899 cropland within Douglas, Howell, and Ozark Counties indicate combined harvested acres of wheat and corn were 58,366; 77,943; and 44,208 respectively (Table Lu01) (MASS 1999). This land use would have undoubtedly contributed significantly to erosion and thus sedimentation and an increased gravel load in the streams of the watershed. As the century progressed, much of the area was found to be unsuitable for this endeavor. Thus, began a period of emigration from the region which, except for a period during the Great Depression, would continue through the 1970s (Robins 1991b).

In the early 1930s, a large portion of land within the North Fork Watershed was purchased by the federal government for the creation of the Mark Twain National Forest (Robins 1991c). Initial natural resource development was accomplished by the Civilian Conservation Corps (CCC); a work program of the Great Depression. Thus, began the era of natural resource management in the area.

An evaluation of present (1993) conditions of Ozark streams, pre-settlement period historical descriptions, stratigraphic observations, and accounts of oral-history responses on river changes during the last 90 years, led Jacobson and Primm (1994) to the conclusion that Ozark streams are disturbed from their natural conditions. They state that this "disturbance has been characterized by accelerated aggradation of gravel, especially in formerly deep pools, accelerated channel migration and avulsion, and growth of gravel point bars". Jacobson and Primm (1994) also suggest that "land use changes have disturbed parts of the hydrologic or sediment budgets or both".

Although detailed data from the North Fork Watershed has not been compiled, Jacobson and Primm (1994) summarized the land use changes from pre-settlement conditions to the 1970's in the Jack’s Fork Watershed (Table Lu02), which borders the North Fork Watershed to the Northeast as follows:

" Different types of land use have taken place on different parts of the landscape, and at different times,

resulting in a complex series of potential disturbances. Uplands have been subjected to suppression of a natural regime of wildfire, followed by logging, annual burning to support open range, patchy and transient attempts at cropping, a second wave of timber cutting, and most recently, increased grazing intensity. Valley side slopes have been subjected to logging, annual burning, and a second wave of logging. Valley bottoms were the first areas to be settled, cleared, and farmed; removal of riparian vegetation decreased the erosional resistance of the bottom lands. More recently, some areas of bottomland have been allowed to grow back into forest. The net effects of this complex series of land-use changes are difficult to determine and separate from natural variability."

Jacobson and Primm (1994) offer the following observations which summarize the probable, qualitative changes to runoff, soil erosion, and riparian erosional resistance on parts of the Ozarks landscape relative to man's impact: "

- Initial settlement of the Ozarks may have initiated moderate channel disturbance because of decreased erosional resistance of cleared bottom lands. This trend would have been countered by decreased annual runoff and storm runoff that accompanied fire suppression in the uplands.
- Because of low-impact skidding methods and selective cutting during initial logging for pine during the Timber-boom period, logging would have had minimal effects on runoff and soil erosion.
- Low-impact methods and selective cutting continued to be the norm in timber harvesting of hardwoods until the late 1940's, when mechanization and diversified markets for wood products promoted more intensive cutting. Locally, log and tie jams, tie slides, and logging debris may have added to channel instability by diverting flow, but because aggradation and instability also occurred on streams not used for floating timber, these factors were not necessary to create channel disturbance.
- Significant channel disturbance probably began in the Timber-boom period because of continued clearing of bottom land forests and road building in the riparian zone. This hypothesis is supported by evidence that significant stream disturbance began before the peak of upland destabilization in the post-timber-boom period. Extreme floods during 1895 to 1915 may have combined with lowered erosional thresholds on bottom lands to produce the initial channel disturbance.
- The regional practice of annual burning to maintain open range had the most potential to increase annual and storm runoff and soil erosion because of its considerable areal extent and repeated occurrence. Burning would have been most effective in increasing runoff and erosion on the steep slopes that had been recently cut over during the timber boom. Generally, accelerated soil erosion was not observed after burning, and relict gullies presently (1993) are not apparent on valley-side slopes and uplands. These observations support the hypothesis that burning did not produce substantial quantities of sediment.
- The greatest potential for soil erosion on valley slopes and upland areas occurred during the post-timber-boom period when marginal upland areas were cultivated for crops. Accelerated erosion of plowed fields was observed and noted by oral-history respondents and by soil scientists working in the Ozarks during the post-timber-boom period.
- Valley bottoms have the longest history of disturbance from their natural condition because they were the first to be settled, cleared, and farmed. The lowered resistance to stream erosion that results from removing or thinning riparian woodland would have been a significant factor, especially on small to medium sized streams for which bank stability and roughness provided by trees are not overwhelmed by discharge. Disturbance of bottom land riparian forest increased as free-range grazing, crop production, and use of valley bottoms for transportation expanded and reached a peak in the post-timber-boom period. Headward extension of the channel network because of loss of riparian vegetation may have increased conveyance of the channel network (and hence flood peaks downstream) and removed gravel from storage in first and second order

valleys at accelerated rates. This hypothesis is supported by a lack of other source areas for gravel and by observations that gravel came from small stream valleys, not off the slopes.

- During present (1993) conditions, channel instability seems somewhat decreased in areas where the riparian woodland has recovered, but stability is hampered by high sedimentation rates because of large quantities of gravel already in transport and effects of instability in upstream reaches that lack a riparian corridor.
- Land use statistics indicate that the present trend in the rural Ozarks is toward increased populations of cattle and increased grazing density. This trend has the potential to continue the historical stream-channel disturbance by increasing storm runoff and sediment supply and thus remobilization of sediment already in transit."

Figures Lu01 and Lu02 show trends in livestock and human populations in the three primary counties of the North Fork Watershed (Douglas, Howell, and Ozark). Livestock populations in all three counties have experienced similar trends throughout the period of record (MASS 1999). The data indicates that the largest increase in livestock populations occurred in the 1970s. These populations have actually leveled off or declined since 1980.

Human population in Douglas and Ozark Counties have experienced similar trends in comparison to each other (OSEDA 1998). Populations of both counties have decreased since the turn of the century.

However, populations have experienced a slight increase since 1970. Data indicates that the Howell County population trend was similar to those of Douglas and Ozark County until 1940. After 1940 populations of Douglas and Ozark Counties experienced a significant decrease while the population of Howell County remained relatively stable. Since 1970 the population of Howell County has significantly increased.

The 1990 human population within the North Fork Watershed was estimated to be 18,052 (Blodgett J. and CIESIN 1996). Population density in 1990 was approximately 13 persons per square mile as compared to the overall population density for Missouri which was approximately 73 persons per square mile (Figure Lu03). Of course, one must take into account the effect of the state’s urban centers on this estimate.

Projections of human population increase of Missouri counties have been calculated by the Missouri Office of Administration (MOA), Division of Budget and Planning for three different projection scenarios in a report entitled "Projections of the Population of Missouri Counties By Age, Gender, and Race: 1990 to 2020" (MOA 1994). Combined population estimates for Howell, Douglas, and Ozark Counties from 1990-2020 have been used to calculate percent increase in population for all three scenarios. The scenarios project a combined population increase of 6.2% to 25.3% by the year 2020.

## Ecological Classification

The Ecological Classification System (ECS) is a management tool which provides a means of "describing distribution of current and potential natural resources in a manner that considers land capability upfront" using a knowledge of landform, geology, soils, and vegetation patterns (MDC 1997a). There are several levels of classification within the ECS. For purposes of this document the three lowest levels are dealt with. These levels are, in descending order, section, subsection, and land type association (LTA). The North Fork Watershed lies within the Ozarks Highlands Section and intersects 3 subsections and 14 LTAs.

The Ozark Highlands Section consists of very old and highly weathered plateaus which, coupled with its physigraphic diversity and central geographic location relative to the continent, has created a region of unique ecosystems harboring many endemic species.

The subsections intersected by North Fork Watershed include the White River Hills, and the Central Plateau. The White River Hills Subsection "is characterized by hilly dissected lands associated with the

North Fork and Bryant Creek valleys. These streams cut principally through Roubidoux and upper Gasconade formations, yielding mainly deep cherty, heavily weathered soils favored by oak-pine woodlands and forests. Gently rolling, moderately dissected Jefferson City-Cotter Dolomite plains occur on the divides between the streams. In addition, unique landscapes with frequent dolomite glade knobs characteristic of this subsection also occur..."(MDC 1997a).

The Central Plateau Subsection "represents the high, flat to gently rolling plains that are the least eroded remnant of the Salem Plateau. Underlain primarily by Jefferson City-Cotter dolomites or Roubidoux sandstone/dolomite, the plains are often mantled in a thin layer of loess and have droughty soils. Streams are mainly intermittent, low gradient headwater streams that are often losing. Savannas and woodlands were originally the dominant vegetation types"(MDC 1997a).

Land Type Associations (LTAs)represent the smallest level of the three levels previously mentioned. LTAs (Figure Lu04) intersecting the North Fork Watershed include the following:

- Ava Oak Woodland Dissected Plain
- Gainesville Oak Woodland Hills
- Howell-Oregon Oak Woodland Dissected Plain
- Romance Oak Woodland Dissected Plain
- Upper Gasconade Oak Woodland Dissected Plain
- Vanzant Oak Woodland Dissected Plain
- West Plains Oak Savanna/Woodland Plain
- Cabool-Mt. Grove Oak Savanna/Woodland Plain
- Bryant Creek Oak-Pine Woodland Forest Hills
- North Fork River Oak-Pine Woodland Forest Hills
- North Fork Pine-Oak Woodland Dissected Plain
- Gainesville Dolomite Glade/Oak Woodland Knobs
- Upper Swan Creek Oak Woodland/Forest Breaks
- North Fork Oak Woodland/Forest Hills

Table Lu03 gives descriptions of LTAs within the watershed.

The Ecological Classification System could prove to be a useful tool for planning and implementing natural resource management activities by providing an indication of what natural resource management options will be more adapted to specific areas thus increasing the success of management decisions as well as helping to ensure that management decisions are ecologically enhancing.

## Current Land Use

The Missouri Resource Assessment Partnership (MoRAP) Phase 1 Land Cover Classification (1997) (morapmd.wpd) data indicates estimated forest/woodland cover within the North Fork Watershed at 61.9% while grassland/cropland comprises 37.5% of the total land cover (Table Lu04, Figure Lu05, Lu06, and Lu07). While forest/woodland is the dominant cover type within the 6 eleven digit hydrologic units (Upper North Fork, Upper Bryant, Lower North Fork, Lower Bryant, West Norfork Lake, East Norfork Lake) of the watershed, the Upper North Fork Hydrologic Unit contains the highest combined percentage of forest/woodland cover at 65.8 percent. This is due in large part to the fact that much of this watershed is in public ownership as part of the Mark Twain National Forest. Fourteen Digit Hydrologic Unit 30001 (a portion of the Spring Creek-North Subwatershed) has the highest percentage of forest/woodland cover at 82.9 percent. This hydrologic unit is composed of large amounts of public land. Fourteen Digit Hydrologic Unit 50005 (a portion of Norfork Lake Drainage) has the lowest percentage of forest/woodland cover at 22.7 percent (Figure Lu07).

## Soil Conservation Projects

As of May 1997, the Douglas and Ozark Counties' Soil and Water Conservation Districts and the Natural Resources Conservation Service are sponsoring a 319 Project in the tributaries of the Bryant Creek watershed which lay in both Douglas and Ozark Counties (Figure Lu08). Other participants include the University of Missouri Cooperative Extension Service, Missouri Department of Natural Resources, and Consolidated Farm Services Agency. The Missouri Department of Conservation is also providing technical advice (Pratt, personal communication). The watershed contains 250,000 acres with a concentration of approximately 70 dairies, 5000 dairy cows and 30,000 beef cattle. The purpose of the project "proposes demonstration practices and an information program to improve or maintain water quality within the tributaries of the Bryant Creek Watershed in Douglas and Ozark Counties." The project is planning 10 BMP (Best Management Practice) demonstration areas. These will include 3 animal waste management farms, 4 grazing management farms, and 3 riparian corridor management/protection farms with alternative watering systems. The project is scheduled to be completed in June of 2002.

Three Special Area Land Treatment (SALT) projects have been located in the North Fork Watershed (CARES 1999). These project areas are the Becky Cobb Creek Watershed (1253 acres treated), Bird Town Hollow Watershed (2470 acres treated), and Clifty Creek Watershed (1450 acres treated). All three projects have ended with the last one, Clifty Creek, ending in mid-summer of 1999 (Figure Lu08) (CARES 1999 and Bruffett, personal communication).

## Public Areas

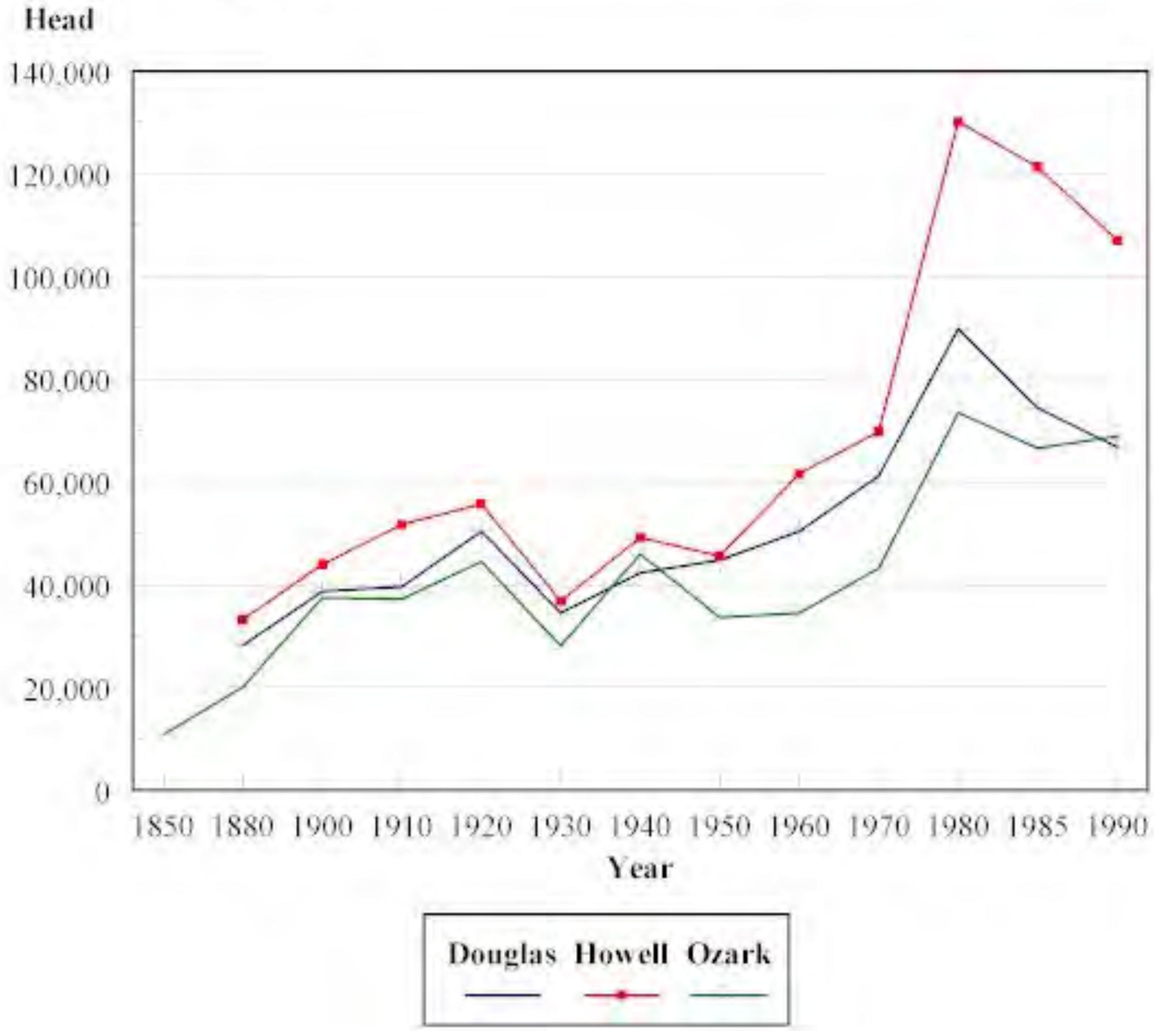
The North Fork Watershed contains approximately 115,205 acres (13.0%) of public land. (Table Lu05 and Figure Lu09). Approximately 89% (102,365 acres) of the public land is part of the Mark Twain National Forest managed by the United States Forest Service. Within the watershed, the United States Army Corps of Engineers (USACOE) owns approximately 5,150 acres in association with Norfork Lake. The Missouri Department of Conservation owns approximately 10,075 acres on 14 areas within the Watershed (MDC 1995). The largest MDC area within the watershed is Caney Mountain Conservation Area which is comprised of 6,674 acres (5,192 acres within the watershed). The MDC also leases an additional 5,150 acres of USACOE property bordering Norfork Lake in Missouri (MDC 1995).

There are 4 public accesses with boat ramps on USACOE property on Norfork lake in Missouri. The United States Forest Service has three public stream accesses. These are located at the North Fork Recreation Area off of CC Highway in Ozark County, Hale Crossing on County Road 275 in Douglas County, and Osborn Crossing located on County Road AH-260 in Douglas County. None of these accesses have a boat ramp. Currently stream access and/or frontage to permanently flowing streams exist on 9 of the 15 areas owned by the Missouri Department of Conservation within the watershed. Of these, 3 areas have boat ramps.

The Missouri Department of Conservation Stream Areas Program Strategic Plan (McPherson 1994) includes the acquisition of two stream access sites within the North Fork Watershed. Also planned within the watershed, through the Stream Areas Program Strategic Plan (McPherson 1994), is the eventual acquisition of eight stream frontage tracts. In addition to expanding public use and access, frontage tracts can provide the preservation of representative, threatened, remnant, or critical stream habitats.

Acquisition of these access sites and frontage tracts will be dependent on property availability and site suitability.

Figure Lu01. Cattle and hog population trends for Douglas, Howell, and Ozark Counties (MASS 1999).



FigureLu02. Human population trends for Douglas, Howell, and Ozark Counties (OSEDA 1998).

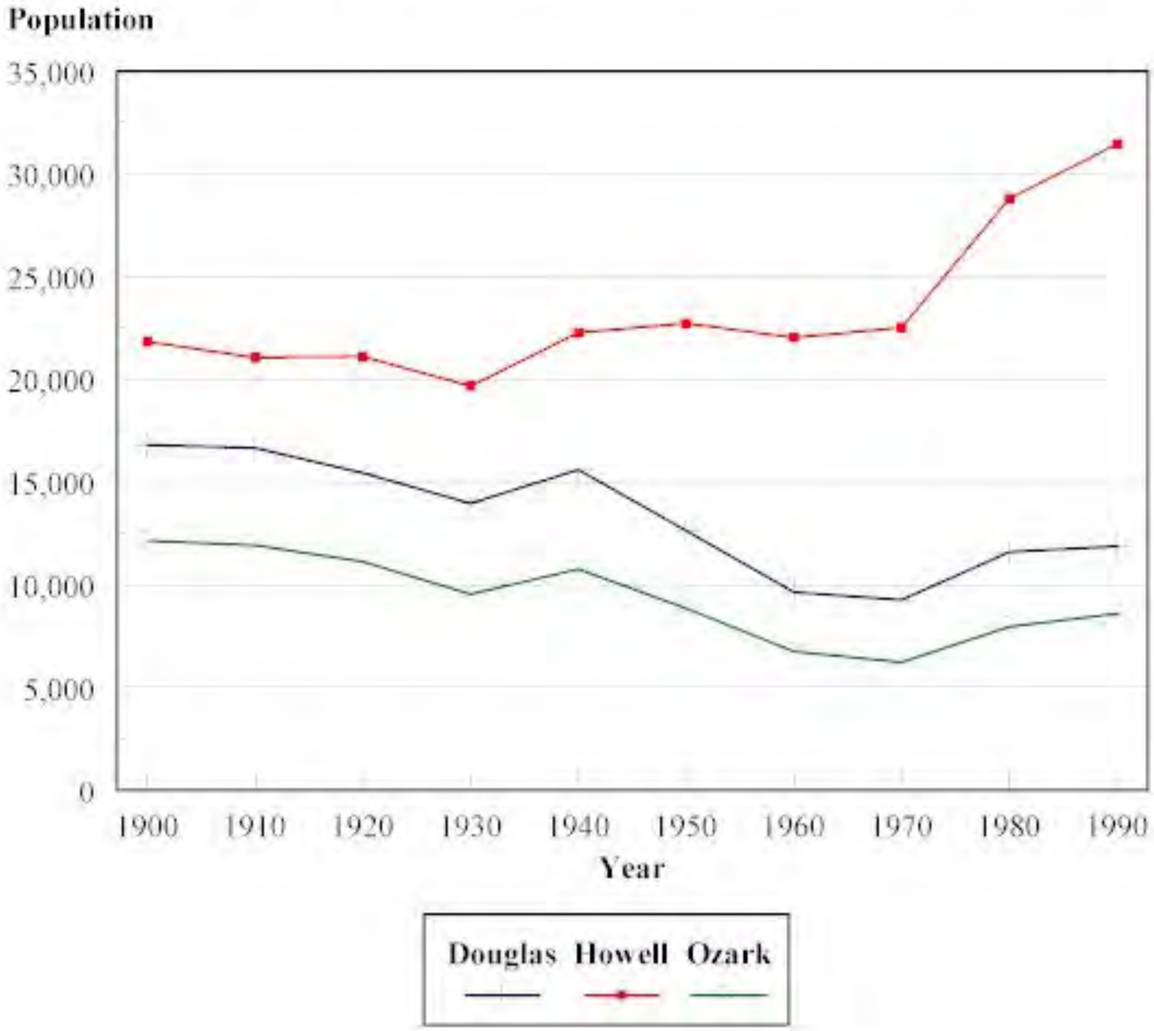


Figure Lu03.

# North Fork Watershed
## Population

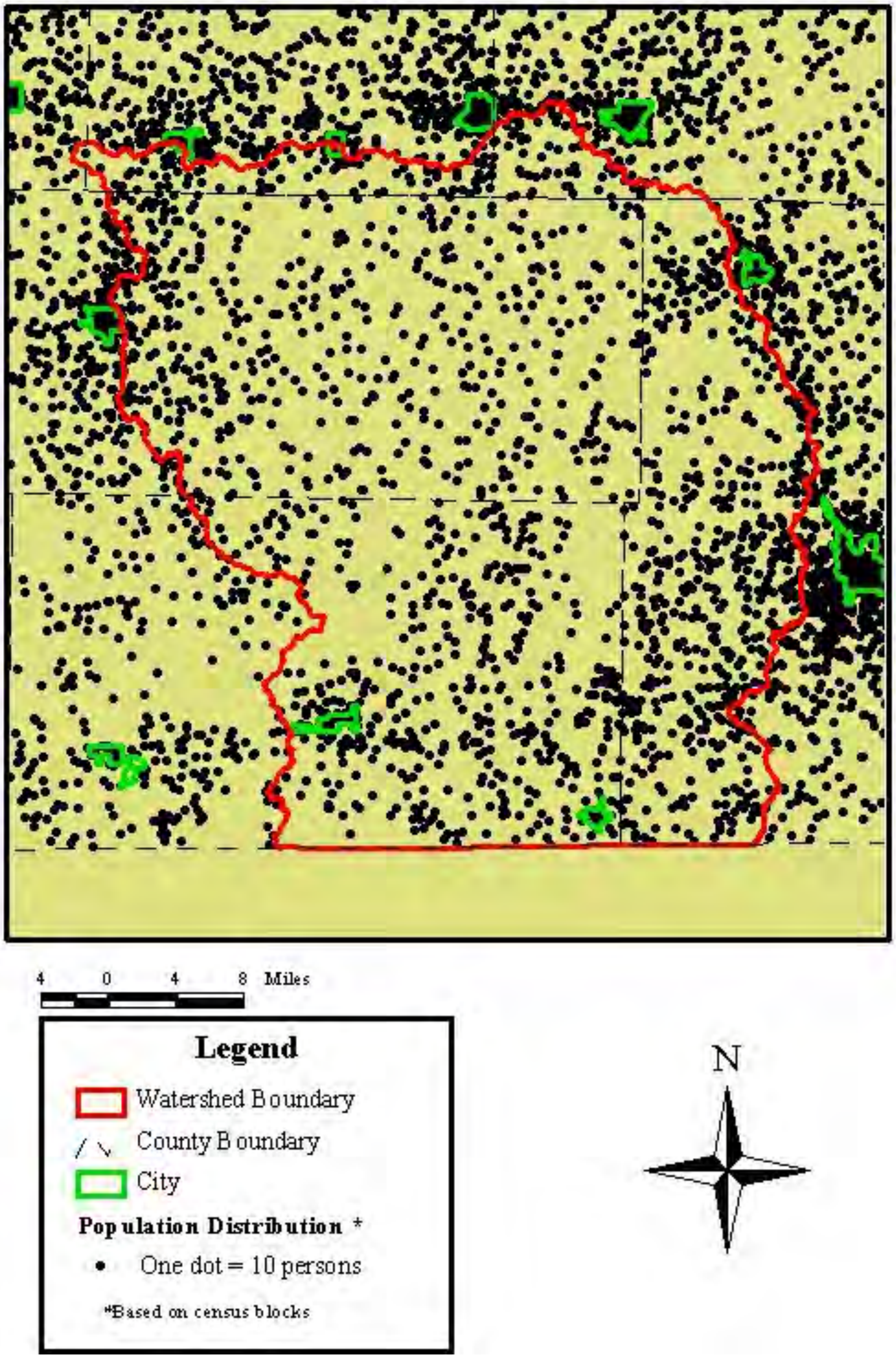


Figure Ln04

# North Fork Watershed
## Land Type Associations

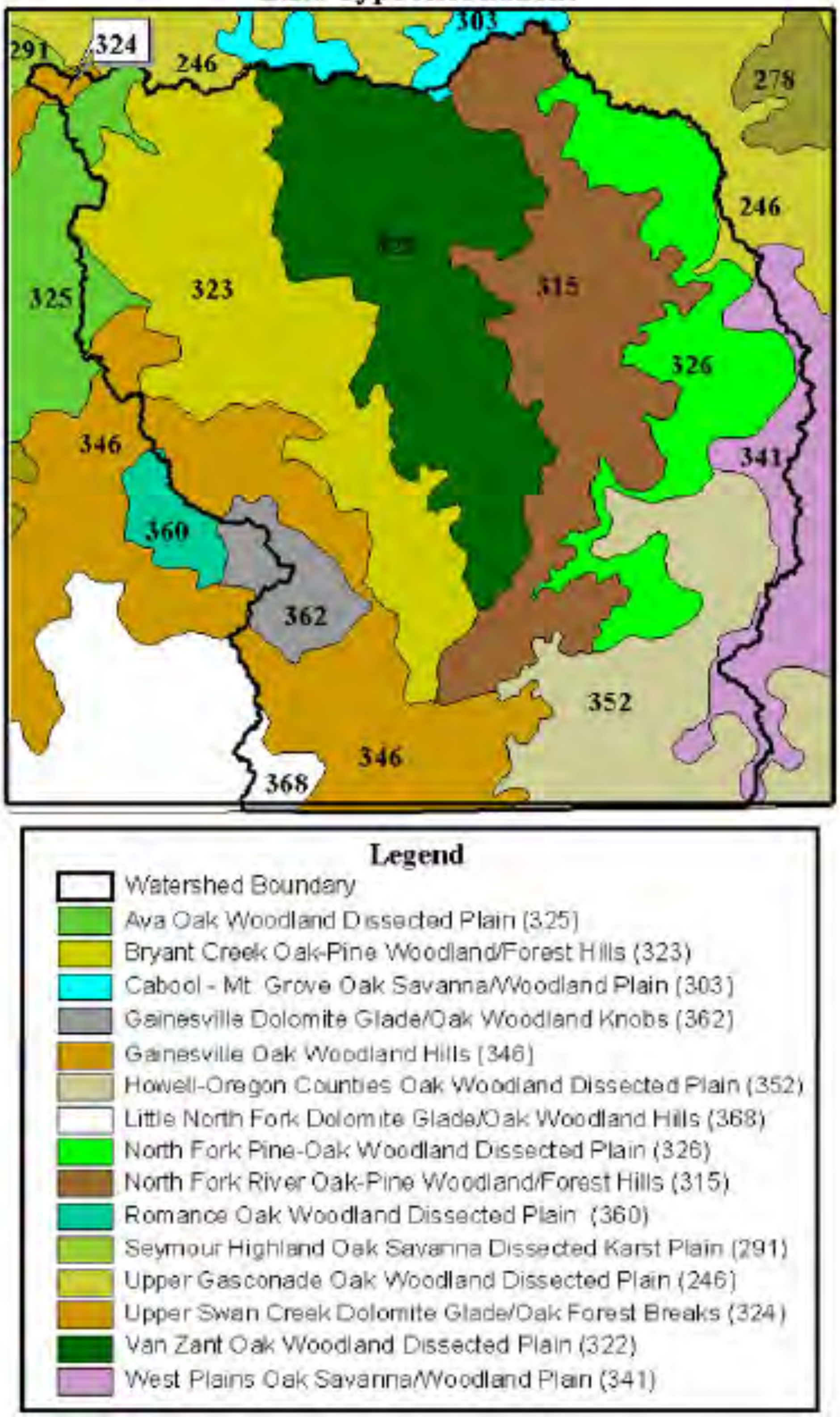


Figure Lu05.

## North Fork Watershed
### Land Cover/Land Use

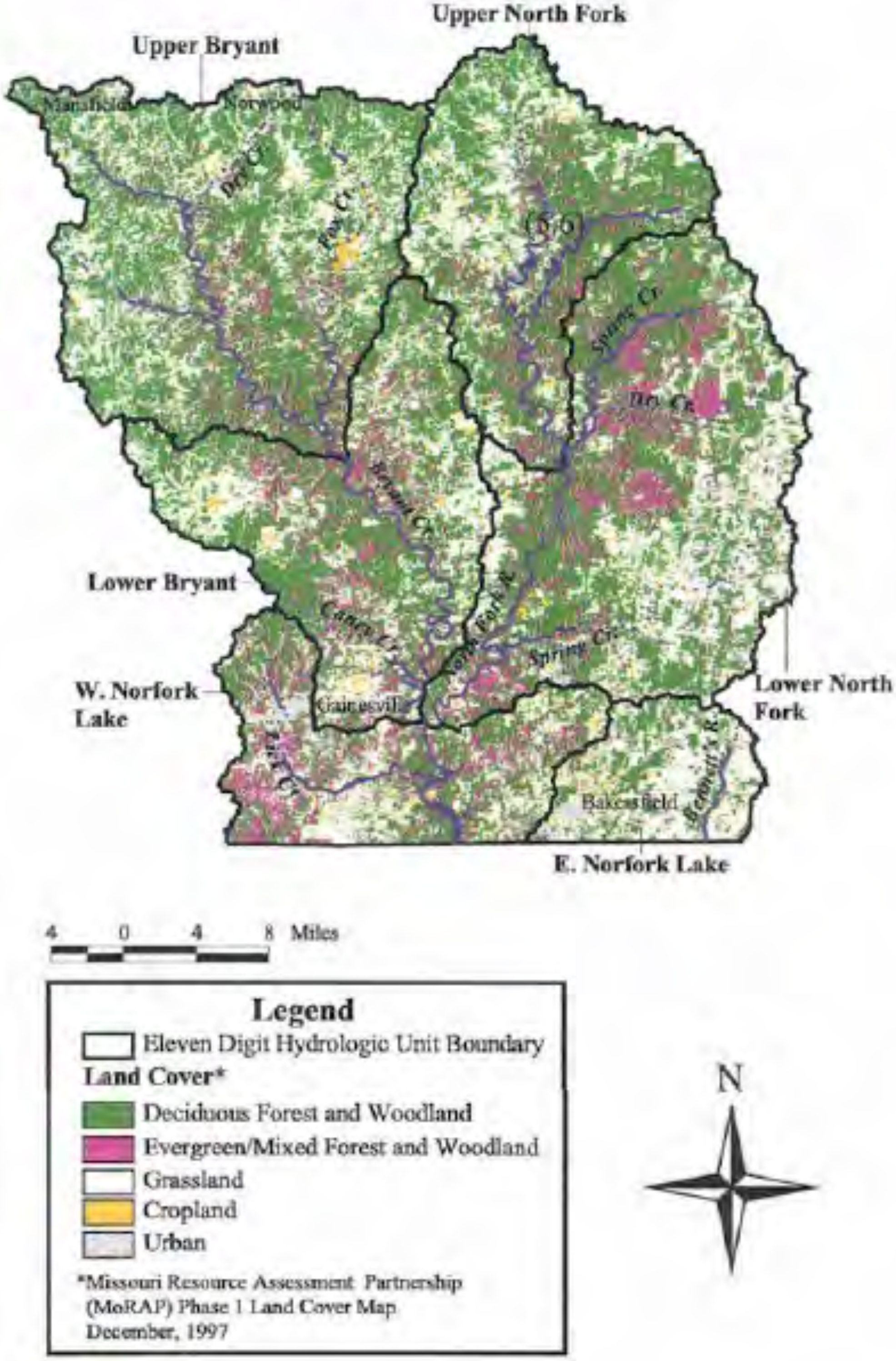


Figure Lu06.

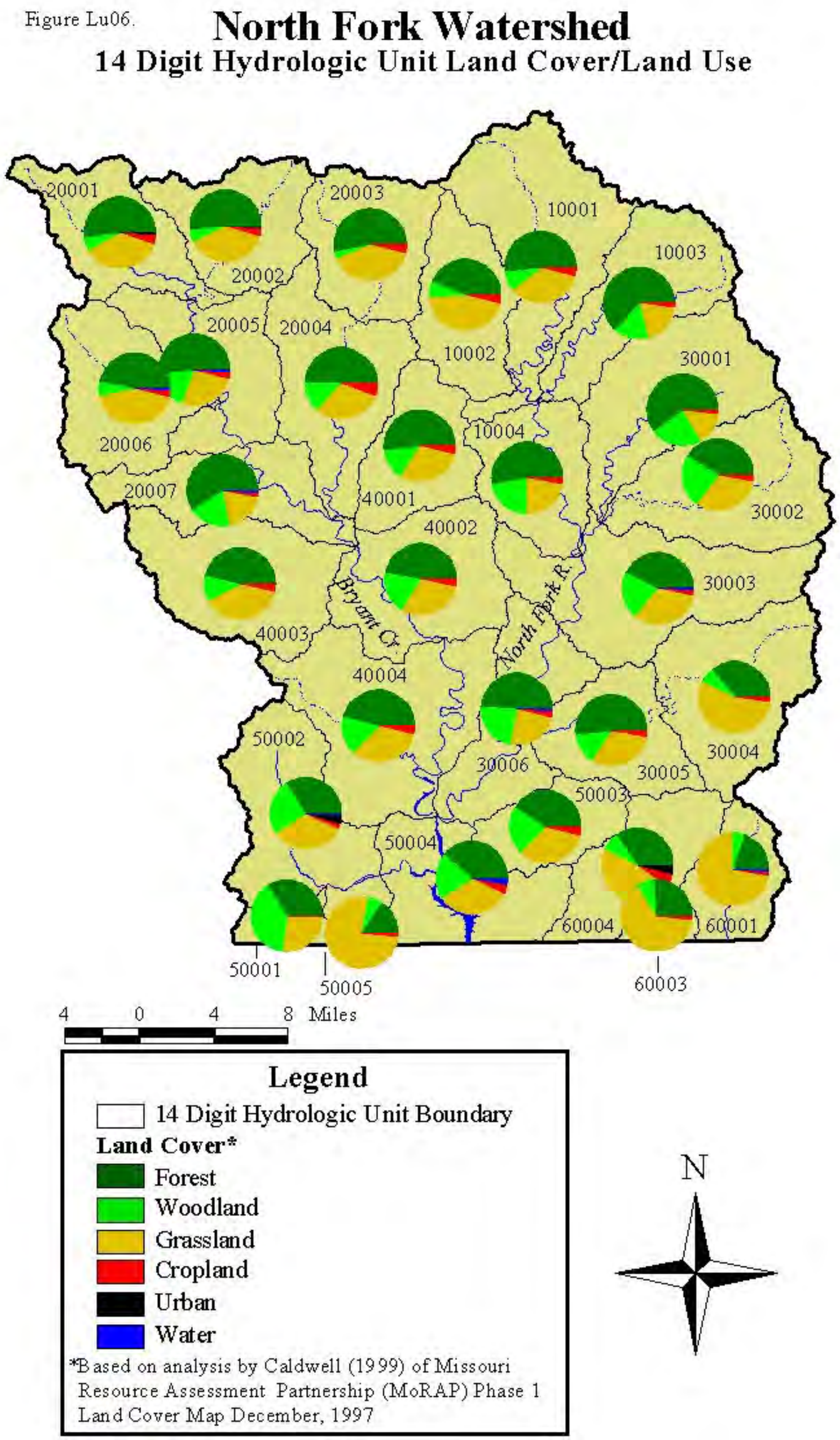

North Fork Watershed
14 Digit Hydrologic Unit Land Cover/Land Use
20001
20002
20003
10001
10003
20005
20004
10002
30001
20006
10004
20007
40001
40002
30002
30003
40003
Bryant Cr.
North Fork R.
40004
50002
30006
30005
30004
50003
50004
60004
60001
50001
50005
60003
4 0 4 8 Miles
Legend
14 Digit Hydrologic Unit Boundary
Land Cover*
Forest
Woodland
Grassland
Cropland
Urban
Water
*Based on analysis by Caldwell (1999) of Missouri Resource Assessment Partnership (MoRAP) Phase 1 Land Cover Map December, 1997
N

Figure Lu07.


North Fork Watershed
14 Digit Hydrologic Unit Forest Woodland Cover
Mansfield
Norwood
Gainesville
Bakersfield
Dry Cr.
Spring Cr.
50005
60001
4 0 4 Miles
Legend
14 Digit Hydrologic Unit Boundary
Percent Forest/Woodland Cover
<25
25 - 50
50 - 75
75 - 100
N

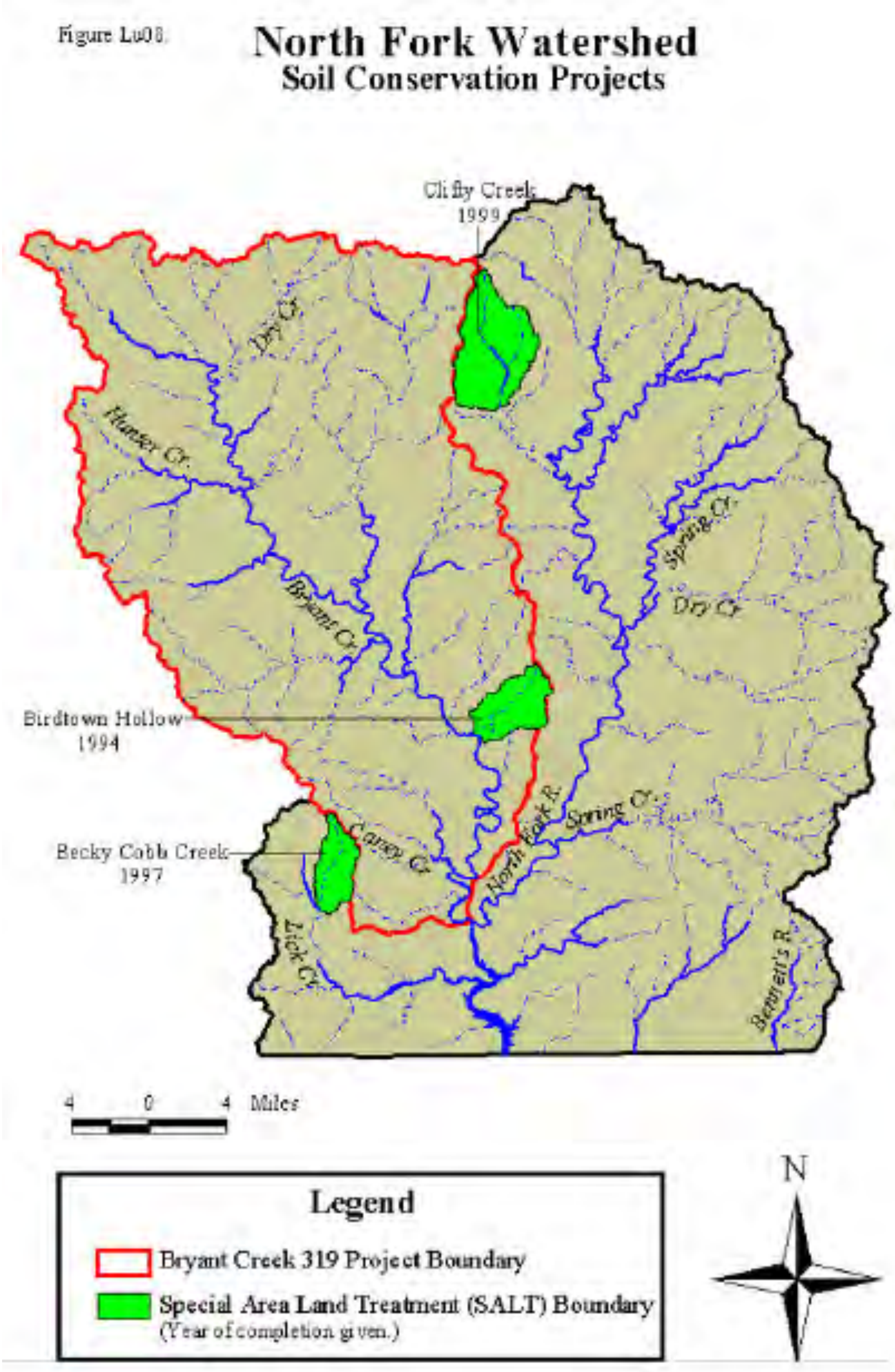


Figure Lu08.
North Fork Watershed
Soil Conservation Projects
Clifty Creek
1999
Dry Cr.
Hunter Cr.
Bryant Cr.
Spring Cr.
Dry Cr.
Birdtown Hollow
1994
Becky Cobb Creek
1997
Caney Cr.
North Fork R.
Spring Cr.
Lick Cr.
Bennett's R.
4 0 4 Miles
Legend
Bryant Creek 319 Project Boundary
Special Area Land Treatment (SALT) Boundary
(Year of completion given.)
N

Table Lu01. Estimated acres of selected crops harvested in Douglas, Howell and Ozark Counties in 1902 and 1997 (MASS 1999)

| | Douglas | | Howell | | Ozark | |
|---|---|---|---|---|---|---|
| **Crop** | 1899 Acres | 1996 Acres | 1899 Acres | 1996 Acres | 1899 Acres | 1996 Acres |
| **Corn** | 43,288 | <500 | 43,737 | <500 | 32,183 | <500 |
| **Hay** | 13,102 | 38,900 | 12,857 | 47,800 | 3,577 | 19,900 |
| **Wheat** | 15,078 | <500 | 29,284 | <500 | 12,025 | <500 |

Table Lu02. Land cover/ land use change from pre-settlement period conditions (1820's) to the 1970's in the Jack's Fork Watershed, Missouri (Jacobson and Primm 1994).

| 1820's | | 1970's | | % |
|---|---|---|---|---|
| Category | Area sq.miles | - | Area sq. miles | |
| **Shrub and brush rangeland** | 55.4 | Urban/developed | 1.6 | 3 |
| | | Pasture/cropland | 26.5 | 48 |
| | | Deciduous forest | 27.3 | 49 |
| **Deciduous forest** | 242 | Pasture/cropland | 59.9 | 25 |
| | | Deciduous forest | 178.6 | 75 |
| **Evergreen forest** | 3.5 | Deciduous forest | 3.5 | 100 |
| **Mixed forest** | 323.1 | Pasture/cropland | 34.5 | 11 |
| | | Deciduous forest | 281.6 | 87 |
| | | Mixed forest | 7 | 2 |
| **Barrens** | 29.2 | Pasture/cropland | 15.5 | 53 |
| | | Deciduous forest | 13.7 | 47 |

Table Lu03. Descriptions of land type association (LTAs) groups as well as a condensed (1 of 6) description of the 15 LTAs (underlined in bold) within the North Fork Watershed. Descriptions are quoted in part or whole from MDC (1997)

## Oak Woodland Dissected Plains and Hills Group

- **Landform:** Distinguished by rolling to moderately dissected topography. Local relief is 75-150 feet. Very broad, flat ridges give way to gentle side slopes and broad stream valleys. Karst plains with frequent shallow sinkhole depressions are common. Broad stream valleys most often occupied by losing streams, however occasional seeps do occur and can spread across substantial portions of a valley.
- **Geology:** Commonly underlain by Jefferson City-Cotter dolomites with a common loess cap. Some minor areas underlain by Roubidoux sandtones.
- **Soils:** Soils are variable, ranging from shallow to bedrock and fragipan soils, to deep, cherty and well-drained loams. Tree root growth is often restricted by bedrock, pans or clay mineralogy, especially high in the landscape.
- **Historic Vegetation:** Open woodlands with occasional prairie and savanna openings was the principal vegetation type. Post oak and black oak were the principal woodland tree species. Historic fire likely played an important role in maintaining an open canopy, sparse understory and a dense herbaceous ground flora. More dissected lands likely contained mixed oak woodland and forest. Unique sinkhole ponds, wet prairies and seeps were scattered in the broad valleys and depressions.
- **Current Conditions:** Currently a mosaic of fescue pasture (35-65% cover) and dense, often grazed oak forest. The transition from open grassland to closed forest is abrupt and the patch work blocky. Very few native grasslands or savannas are known, and the dense second growth woodlands have very little ground flora. Most sinkoles, wet prairies and seeps have been drained and heavily grazed. Many roads, towns, cities and businesses are located in these LTAs.
- **Ava Oak Woodland Dissected Plain:** Gentle Dissected Plains in headwaters of Beaver Creek.
- **Gainville Oak Woodland Hills:** Dissecte Hills in upper reaches of Little North Fork Drainage. This LTA is more dissected and timbered than others in group.
- **Howell-Oregon Oak Woodland Dissected Plain:** Dissected Plain in southern Howell and Oregon Counties. More dissection, better soils, and more existing timber than most other LTAs in this group.
- **Romance Oak Woodland Dissected Plain:** Small dissected plain on divide between Little North Fork and Bryant Creek.
- **Upper Gasconade Oak Woodland Dissected Plain:** Broad divide encompassing the headwaters of the Big Piney and Gasconade River Watersheds.
- **Vanzant Oak Woodland Dissected Plain:** Divide between North Fork River and Bryant Creek.

## Oak Savanna/Woodland Plains Group

- **Landform:** Very broad flat uplands slope gently to very broad flat drains or solution (karst) depressions. Local relief is less than 75 feet.
- **Geology:** Underlain mainly by Jefferson City-Cotter dolomites with a common loess cap. Minor areas of the Roubidoux formation occur. Headwater streams are nearly all losing.
- **Soils:** Fragipan soils or soils with shallow restrictive clays or bedrock are common, inhibiting tree root growth.
- **Historic Vegetation:** Oak savannas and woodlands with common prairie openings were the predominant historic vegetation. While few prairies were named by original land surveyors, early descriptions portray an open, "oak prairie" landscape. Fire likely played a principal role in

maintaining a grassland-open woodland structure. Some sinkhole depressions would have had unique ponds and seeps.

- **Current Conditions:** The largest blocks and greatest acres of grassland (45-65% cover) are currently associated with these LTAs; grasslands are mainly fescue pasture. Less than 40% of these LTAs are timbered, mainly in dense, second growth oak forest (post and black oaks) with common grazing pressure. Very few quality native prairies, savannas, woodlands, sinkhole ponds or seeps are known. Many of the regions roads, towns, and businesses are associated with these LTAs.
- **West Plains Oak Savanna/Woodland Plain:** Very extensive, flat upland in the center of Howell County.
- **Cabool-Mt. Grove Oak Savanna/Woodland Plain:** Two narrow, high, flat divides between the Upper Gasconade and North Fork Drainages.

### Oak-Pine Woodland Forest Hills Group

- **Landform:** Mainly broad ridges, moderately sloping (<25%) side slopes, and relatively broad entrenched valleys with local relief between 150-250 feet. Steeper, more dissected areas occur locally near larger stream valleys. Sinkhole depressions are common on broader ridges. Stream valleys vary somewhat from broad and rather shallow, to more deeply entrenched, narrow, and meandering. Many losing streams occur in valleys distant from the main rivers. Cliffs, caves and springs are commonly associated with larger, perennial stream valleys.
- **Geology:** Roubidoux cherty sandstones and dolomites occupy most ridges and upper side slopes, while lower side slopes, especially near major streams are in cherty upper Gasconade dolomite materials.
- **Soils:** Soils are mainly deep, highly weathered and very cherty silt loams with clays at varying depth. Broad ridges may have a loess cap with occasional fragipans, and shallow soils with dolomite bedrock near the surface occur frequently on steeper, exposed slopes.
- **Historic Vegetation:** Pine and mixed oak-pine woodland originally dominated the more gently sloping upland surface associated with the Roubidoux Formation. Early descriptions portray an open, grassy and shrubby understory in these woodlands, a condition related to the prevalence of fire in the historic landscape. Oak and oak-pine forest occupied lower slopes and more dissected, hilly parts of these landscapes, as well as the wider and more well-drained bottom. Bottoms with richer alluvial soils and more abundant water likely were forested in mixed hardwood timber.
- Dolomite glade and open savanna/woodland complexes were common on exposed slopes with shallow soils. Sinkhole ponds and fens were dotted occasionally throughout.
- **Current Conditions:** Mainly forested in second growth oak and oak-pine forests; forest cover ranges from sixty to over 80%. Most forests are rather dense, near even-age second growth, with very little woodland ground flora. The occurrence of shortleaf pine in these forests has diminished from its original extent, today having only 20-30% of the forest cover containing a substantial component (>25%) of pine. Even age stands dominated by scarlet, black, and white oak are common, oak die back is a common problem. Much of the existing timber land is associated with public land ownership. Cleared pasture lands occupy many of the broad stream valleys and highest, flattest ridges. Many glades and woodlands suffer from woody encroachment, and sinkhole ponds and fens have been drained or severely overgrazed. An exceptional proportion of state-listed species sites are associated with the streams, springs, caves, cliffs, fens, and sinkhole ponds in this group.
- **Bryant Creek Oak-Pine Woodland Forest Hills:** Includes most of the valley. This LTA has the lowest relief, forest cover, and pine component in group.
- **North Fork River Oak-Pine Woodland Forest Hills:** Include most of valley; exceptional pine component and U.S. Forest Service ownership.

## Pine-Oak Woodland Dissected Plains

- **Landform:** Broad, flat to gently rolling plains which give way to moderately dissected and sloping lands associated with the headwaters of major drainages. Valleys are broad and local relief 100-150 feet. Clusters of karst sinkholes are common. Streams are mainly headwater streams with flashy, intermittent flow.
- **Geology:** Underlain by cherty sandstone and dolomite of the Roubidoux Formation with frequent loess deposits on the flatter uplands.
- **Soils:** Soils are formed principally in cherty sandstone and dolomite residuum from the Roubidoux Formation. Soils are mainly deep, cherty, and highly weathered, low base soils. However occasional fragipans and shallow to bedrock soils do occur. Most soils are extremely well drained and droughty.
- **Historic Vegetation:** Originally covered in woodlands of shortleaf pine and mixed pine oak with an open understory of dense grass and shrub ground cover. Post oak woodlands occupied occasional loess covered flats. Unique sinkhole ponds dotted the landscape.
- **Current Conditions:** Over 75% of this group are currently forested in dense, even-age oak and oak-pine forest. Only 20% of these forests have a strong pine component. However, the proportion of forests containing shortleaf pine is the highest in this group. Dense stands of near even age scarlet, black, and post oak occur in the place of pine. Understories are dense, woodland ground flora sparse, and oak die-back common. A substantial component of these forested lands are publicly owned. Approximately 20% of this group is currently pasture, which often occupies the broad valley bottoms or karst plains. Most sinkhole ponds have been drained, dozed or severely overgrazed. Headwater streams are subject to grazing and bank erosion.
- **North Fork Pine-Oak Woodland Dissected Plain:** Flat to rolling landscape along the eastern edge of the North Fork Hills.

## Dolomite Glade/Oak Woodland Knobs

- **Landform:** Prominent dolomite knobs and high extended ridges which, as erosional remnants, rise above the surrounding landscape.
- **Geology:** Jefferson City-Cotter dolomites form the core of this landscape. Knobs often have a cap of cherty Mississippian limestone. The cap often exists as residual, very cherty sediments left from millennia of erosion.
- **Soils:** Soils in the uplands are mainly shallow to bedrock with varying amounts of cherty residual overburden. The thin soils support extensive unique dolomite glade and oak savanna/woodland complexes. Deeper soils are mainly cherty loams formed from the cherty residual limestone and dolomite materials.
- **Historic Vegetation:** Extensive open and thinly wooded areas. Oak woodland and forests were confined to the roughest land and valleys. The extensive open glades and savannas supported numerous unique species, many found only on these habitats in the White River Hills subsection. Fire history studies indicate frequent (3 year fire free interval) fire in these landscapes prior to settlement
- **Current Conditions:** Most of the dolomite glades and woodlands have grown up in thick stands of eastern red cedar and other invaders. In addition, widespread grazing pressure has lowered the diversity of many glade/woodland areas. Efforts to reintroduce fire and eliminate woody species encroachment has had substantial success on a limited number of acres. Caney Mountain C.A. and the Ava District of the Mark Twain National Forest encompass a significant portion of these LTAs.
- **Gainesville Dolomite Glade/Oak Woodland Knobs:** Encompasses the Gainesville Monadocks, a prominent set of unique knobs. Caney Mountain C.A. occupies a large portion of this LTA.

### Oak Woodland Hills and Breaks

- **Landform:** This Group exhibits relatively rough topography with local relief of 150-250 feet. The Upper Swan Creek Breaks represent a more abrupt steep and intricately dissected landscape than the North Fork Hills.
- **Geology:** The Geology of this Group is primarily composed of the Jefferson City-Cotter formations. Scattered dolomite knobs are interspersed through relatively rugged hills. In addition the uplands in Upper Swan Creek frequently have a cap of cherty Mississipian limestone.
- Soils: Areas of shallow soils are frequent with deeper cherty loam soils above and below them.
- **Historic Vegetation:** Likely, common dolomite glade and cherty savanna/woodland complexes on steep sideslopes. Oak woodland and forest occupied deeper soils, especially along valleys.
- **Current Conditions:** Broader, flat to gently rolling uplands and broad bottoms are currently fescue pasture. This is especially true in the North Fork Hills. Glades and Savannas are extensively overgrown with eastern red cedar and other woody species; and suffer from a history of intense grazing. Forest consists of mainly second growth oak in various mixes. Mainly private ownership.
- **Upper Swan Creek Oak Woodland/Forest Breaks:** Rugged hills with abrupt breaks into upper Swan Creek Valley.
- **North Fork Oak Woodland/Forest Hills:** More typically rolling to dissected hills landscape with common glade/woodland complexes.

Table Lu04. Percent land use for 14 digit and 11 digit (in bold) hydrologic units within the North Fork Watershed. Data is based on MORAP Phase 1 Land Cover (1997) as analyzed by Caldwell (1998).

| Subwatershed | FOR | WDL | GRS | CRP | URB | WAT |
|---|---|---|---|---|---|---|
| **10001** | 51.9 | 9.2 | 35.2 | 3.5 | <0.1 | <0.1 |
| **10002** | 43.6 | 6.7 | 45.3 | 4.5 | 0 | <0.1 |
| **10003** | 63.2 | 15.7 | 19.1 | 1.9 | 0 | 0.1 |
| **10004** | 52.9 | 21.5 | 22.6 | 2.8 | 0 | 0.2 |
| **Upper North Fork** | 53.2 | 12.6 | 30.9 | 3.2 | <0.1 | 0.1 |
| **20001** | 51.9 | 6.2 | 37.5 | 3.7 | 0.6 | <0.1 |
| **20002** | 51.8 | 5.4 | 37.8 | 3.8 | 1.2 | <0.1 |
| **20003** | 52.9 | 3.3 | 39.6 | 4.1 | 0 | <0.1 |
| **20004** | 50.2 | 13 | 31 | 5.7 | 0 | <0.1 |
| **20005** | 52.3 | 17.4 | 27.2 | 3 | 0 | 0.1 |
| **20006** | 47.2 | 5.7 | 43.4 | 3.5 | 0.2 | <0.1 |
| **20007** | 59.4 | 19.3 | 18.8 | 2.3 | 0 | 0.2 |
| **Upper Bryant** | 52 | 10.1 | 33.8 | 3.8 | 0.3 | <0.1 |
| **30001** | 60.2 | 22.8 | 15 | 1.9 | 0 | 0.3 |
| **30002** | 41.1 | 23.6 | 32.4 | 2.5 | 0 | <0.1 |
| **30003** | 43.4 | 20.9 | 33.5 | 2 | 0 | 0.2 |
| **30004** | 36.1 | 6.9 | 55.1 | 1.8 | 0 | <0.1 |
| **30005** | 51.9 | 14.1 | 30.8 | 3.2 | 0 | <0.1 |
| **30006** | 49.4 | 22.6 | 24.3 | 3 | 0 | 0.7 |
| **Lower North Fork** | 46.6 | 18.7 | 32.5 | 2.3 | 0 | 0.2 |
| **40001** | 52.3 | 13.7 | 29.8 | 4.1 | 0 | <0.1 |
| **40002** | 46.8 | 18.9 | 30.9 | 3.2 | 0 | 0.2 |
| **40003** | 45.7 | 11.7 | 38.2 | 4.3 | 0 | 0.1 |
| **40004** | 45.7 | 17.5 | 32.7 | 3.7 | 0.1 | 0.3 |
| **Lower Bryant** | 47 | 15.7 | 33.2 | 3.8 | <0.1 | 0.2 |
| **50001** | 34.2 | 38.6 | 25.9 | 1.2 | 0 | 0 |
| **50002** | 34.4 | 25.2 | 34 | 2.4 | 4 | <0.1 |

| Subwatershed | FOR | WDL | GRS | CRP | URB | WAT |
|---|---|---|---|---|---|---|
| **50003** | 41.5 | 21.6 | 32.7 | 4.2 | 0 | <0.1 |
| **50004** | 38.8 | 19.8 | 34.5 | 4 | <0.1 | 3.1 |
| **50005** | 16.4 | 6.2 | 75.8 | 1.6 | 0 | 0 |
| **West Norfork Lake** | 36.9 | 23.5 | 33.9 | 3.1 | 1.6 | 1 |
| **60001** | 20.2 | 5.4 | 71.9 | 2.5 | 0 | <0.1 |
| **60003** | 25.9 | 8 | 64.5 | 1.6 | 0 | 0 |
| **60004** | 35.2 | 8.1 | 47.4 | 5.6 | 3.7 | <0.1 |
| **East Norfork Lake** | 28.7 | 7.1 | 58.2 | 4 | 1.9 | <0.1 |
| **North Fork Watershed** | 46.9 | 15 | 34.2 | 3.3 | 0.4 | 0.2 |

**FOR** =Forest, **WDL**=Woodland, **GRS**=Grassland, **CRP**=Cropland, **URB**=Urban, **WAT**=Water

Table Lu05. Public lands within the North Fork Watershed. For areas only partially within the watershed, total acreage is given in parenthesis. (MDC 1995).

| Name | Owner[1] | Acres[2] | Stream (miles)[3] |
|---|---|---|---|
| **Blair Bridge Access** | MDC | 7 | 0.2 |
| **Blueslip Towersite** | MDC | 3.6 (4.6) | 0 |
| **Cedar Gap CA** | MDC | 384 | 0 |
| **Caney Mountain CA** | MDC | 5192.0 (6,674.0) | 0 |
| **Florence C. Cook Access** | MDC | 4.7 | 0.4 |
| **Hebron Access** | MDC | 12 | 0.3 |
| **Mark Twain National Forest** | USFS | 102,365.00 | 46.2 |
| **Norfork Lake** | USACOE | 5,150.00 | 2.5 |
| **Patrick Bridge Access*** | MDC | 161 | 1.1 |
| **Rippee CA** | MDC | 418 | 2.5 |
| **Shannon Ranch CA** | MDC | 1,325.00 | 0 |
| **Sycamore Access*** | MDC | 16 | 0.3 |
| **Tecumseh Towersite** | MDC | 40 | 0 |
| **Timber Knob Towersite** | MDC | 40 | 0 |
| **Vera Cruz Access** | MDC | 80 | 0.6 |
| **Warren Bridge Access*** | MDC | 7 | 0.3 |
| **TOTAL** | - | 115,205 | 54.4 |

**Note:** This table is not a final authority. Data subject to change.

[1]Owner: MDC=Missouri Department of Conservation. USCOE=United States Corps of Engineers. USFS=United States Forest Service.

[2]Estimates are approximate.

[3]Permanent Stream (Estimates are approximate.)

*No boat ramp at access.

# Hydrology

## Precipitation

The North Fork Watershed is situated in one of the wetter parts of the state. Data available from the National Climatic Data Center (NCDC 1999) for 10 National Weather Service and cooperative stations located in and near the watershed, indicate an average annual precipitation of 43.26 inches for the period of 1946 to1995(Figures Hy01 and Hy02). This time period has been chosen for analysis of certain hydrological characteristics of the watershed in order to make use of the most complete and long-term precipitation and discharge data available. The maximum recorded annual precipitation amount at an individual station during this period is 65.37 inches, while the minimum recorded annual precipitation during this period is 20.31 inches.

Average annual precipitation in the watershed has increased over time. A comparison of average annual precipitation for two time periods, 1946 to1970 and 1971 to1995, indicates an increase of 2.55 inches within the watershed. Figure Hy02 shows annual precipitation amounts as well as average annual amounts for the previously discussed time periods. Average monthly precipitation data for the period 1946-1995 indicates that the combined months of April, May, and June receive the most precipitation at 13.42 inches. The combined months of December, January, February receive the least amount of precipitation at 8.45 inches. Average monthly precipitation data also indicates that May receives the most precipitation while January receives the least (Figure Hy03). Distribution of monthly precipitation amounts has shifted over time. Average monthly precipitation comparisons between the periods 1946 to 1970 and 1971-1995 indicate an increase in precipitation in 8 of the months, while the other 4 months have experienced a decrease in precipitation. The most notable change has been an increase in the amount of average monthly precipitation occurring in the months of September, October, November, and December (Figure Hy04).

## United States Geological Survey Gauging Stations

The United States Geological Survey (USGS) currently (1999) has two active stream discharge gaging stations within the North Fork River Watershed. Station #07057500 is located on the North Fork River, 3.5 miles northeast of Tecumseh upstream from Dawt Mill (USGS 1999a). The datum of the gage is 584.67 ft above sea level. Station #07057500 has been recording water stage data from October 1944 to the present. Station #07058000 is located on Bryant Creek 0.8 miles downstream from Caney Creek near Tecumseh (USGS 1997). The datum of the gage is 573.15ft above sea level (USGS 1997) (Figure Hy01). Historical records from station #070578000 exist from 1944-1985 1994-1996, and 1997-1998. Historical water stage and discharge records exist from eleven other sites positioned throughout the watershed (Table Hy01 and Figure Hy01) (MDNR 1994, USGS 1998, and USGS 1999b).

## Average Daily Discharge

Long-term discharge data exists for the two operational gage stations, one on the North Fork River near Tecumseh (07057500) and the other on Bryant Creek near Tecumseh (07058000). The average daily discharge at gage station 07057500 for the last 54 years is 756 cubic feet per second (cfs) with the number of observations (n) equaling 19,723 (USGS 1999c). The average daily discharge at gage station 07058000 for the 43 years of record is 534 cfs (n=16,121) (USGS 1999d). Average daily discharge at both stations was lowest during the months of August, September, and October and highest during March, April and May (Figures Hy05 and Hy06). Comparison of two time periods, 1946 to 1970 and 1971 to 1995 indicates a substantial increase in average daily discharge at both stations 07057500 and 07058000 during the latter time period. Station 07057500 has experienced an increase of 134 cfs while Station 07058000 has experienced an increase of 85 cfs. Analysis of percent change in average daily discharge by month

between two time periods indicates a substantial increase in the months of March, April, September, November, and December coupled with a notable decrease in July (Figure Hy04).

Months with the lowest amount of precipitation do not necessarily exhibit the lowest flows within the watershed. As indicated previously, the combined winter months of December, January, February receive the least amount of precipitation. However, the lowest daily flows occur during the late summer/early fall months of August, September, and October. Increased evaporation and transpiration rates during this period may explain this.

## Flow Duration

Flow duration curves are useful for inter/intra watershed comparisons of discharges. Daily flow duration data available from the United States Geological Survey (USGS) Daily Values Statistical Program (DVSTAT) (1999e) was compared to determine if the North Fork River and Bryant Creek had become more or less susceptible to flooding or drying in recent years. Figure Hy07 indicates the duration of flows from 1946 through 1970 and 1971 through 1995 on the North Fork River near Tecumseh. Figure Hy08 indicates the duration of flows from 1946 to 1970 and 1971 through 1985 plus data from 1994 and 1995 on Bryant Creek near Tecumseh.

The flow duration curves from the latter time period have made an upward shift indicating higher discharges at both stations. The upward shift of the flow duration curve reflects, in part, an overall increase in discharge in the latter time period. The changes in the flow duration curve and discharge rates are an indication of possible changes in precipitation, land use, and/or spring output. Changes in the amount, intensity, seasonal timing, and/or duration of precipitation could impact discharge. As stated previously, the area of the watershed has experienced an overall increase in average annual precipitation during the last 25 years. In addition, seasonal timing of this rainfall has changed over the past 25 years (Figure Hy04). Data on intensity and duration of precipitation is unavailable. Land use practices can significantly alter flow duration and discharge. A change in land use from pasture or clear-cut to timber can slow the rate of surface runoff, alter the ratio of surface to subsurface flow, and reduce over-bank flow velocities. The variability of land use data collection methodology and analysis makes it difficult to reliably determine actual land use/land cover changes which have occurred within the watershed for the previously discussed time periods. If significant changes have occurred, it would seem that changes in the slopes of the flow duration curves would be apparent. However, while the curves have shifted upward for both stations (probably due to increased precipitation), neither has experienced a significant change in slope. Thus, flow duration does not appear to have been significantly altered by any change in land use in the watershed.

A comparison of flow duration curves for the time period 1946-1995 for both the North Fork River and Bryant Creek stations indicate a slightly steeper curve for Bryant Creek (Figure Hy09). This is perhaps due to the fact that a large amount of water within the upper portion of Bryant Creek is thought to be lost to the ground water system to reemerge in the North Fork thus sustaining the latter for extended periods of time. Another explanation is that perhaps the slightly lower percentage of forest/woodland cover within the Bryant Creek Subwatershed promotes an increased rate of runoff which decreases the sustainability of discharges over time. However, the percentage difference is so negligible (<5%), that it is difficult to determine, with certainty, if this is one of the primary causes. In addition, average gradients for fourth order and larger streams within the Bryant Creek Subwatershed are slightly higher than those of streams in the North Fork Drainage above Bryant Creek. This would lead to a higher rate of runoff and thus a steeper flow duration curve.

## 10:90 Ratio

The ratio of the flow rate which is equaled or exceeded 10% of the time to the flow rate which is equaled or exceeded 90% of the time is called the 10:90 ratio. The 10:90 ratio for the North Fork River near

Tecumseh is 5:1. The 10:90 ratio for Bryant Creek near Tecumseh is 8:1. The 10:90 ratios at both of these sites are considered low. Low 10:90 ratios are indicative of low overall flow variability. In the North Fork Watershed, ground water contributes significantly to the overall water supply to the North Fork and Bryant Creek. Therefore, flow in these streams would be less affected by fluctuations in precipitation amounts over relatively short periods of time than streams with higher ratios.

## Instantaneous Discharge

Table Hy02, lists the highest and lowest instantaneous discharge rates that have occurred at each of the above sites during the period of record.

## 7-day $Q^2$, $Q^{10}$, $Q^{20}$ Low Flow and Slope Index

Seven day low flow statistics were computed for the two currently operating gage stations within the North Fork Watershed. The North Fork River near Tecumseh has seven day $Q^2$ and $Q^{20}$ low flow values of 295 and 195 cfs, respectively. Bryant Creek near Tecumseh has seven day $Q^2$ and $Q^{20}$ low flow values of 150 and 100 cfs, respectively.

Slope indices (SI, ratio of the seven day $Q^2$ to $Q^{20}$) were calculated for the North Fork River near Tecumseh and Bryant Creek near Tecumseh. The SI were 1.5 for both sites. These are extremely low slope indices, an indication of low variability in annual low flows.

## Flood Frequency

Table Hy03 indicates the frequency and magnitude of flooding on the North Fork River and Bryant Creek near Tecumseh. The watershed areas above the gage stations on the North Fork River and Bryant Creek are 561 and 570 square miles, respectively (USGS 1997 and USGS 1999a). As the similarities in the size of the watersheds would suggest, the flood frequency and magnitudes on the North Fork River and Bryant Creek are very similar to each other. The frequency and magnitude of the floods on the North Fork River and Bryant Creek are comparable to streams of similar size within the Ozark Region.

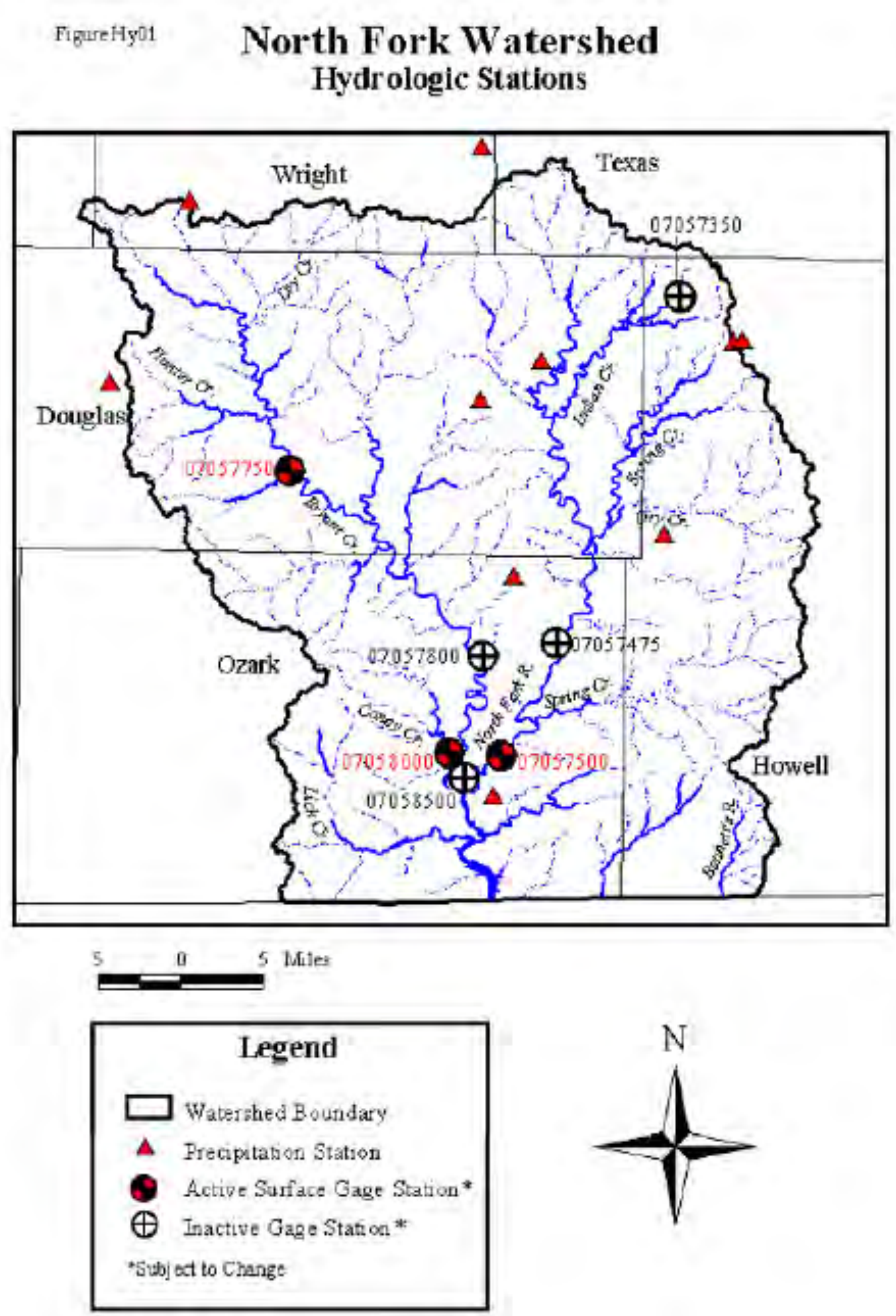


Figure Hy01
North Fork Watershed
Hydrologic Stations
Wright
Texas
Douglas
Ozark
Howell
07057350
07057750
07057800
07057475
07058000
07057500
07058500
Dry Cr.
Indian Cr.
Spring Cr.
North Fork R.
Bryant Cr.
5 0 5 Miles
Legend
Watershed Boundary
Precipitation Station
Active Surface Gage Station*
Inactive Gage Station*
*Subject to Change
N

Figure Hy02. Mean annual precipitation amounts from National Weather Service and cooperative stations in and near the North Fork Watershed for years 1946-1995 (NCDC 1999). n=number of annual measurments available for period of record.

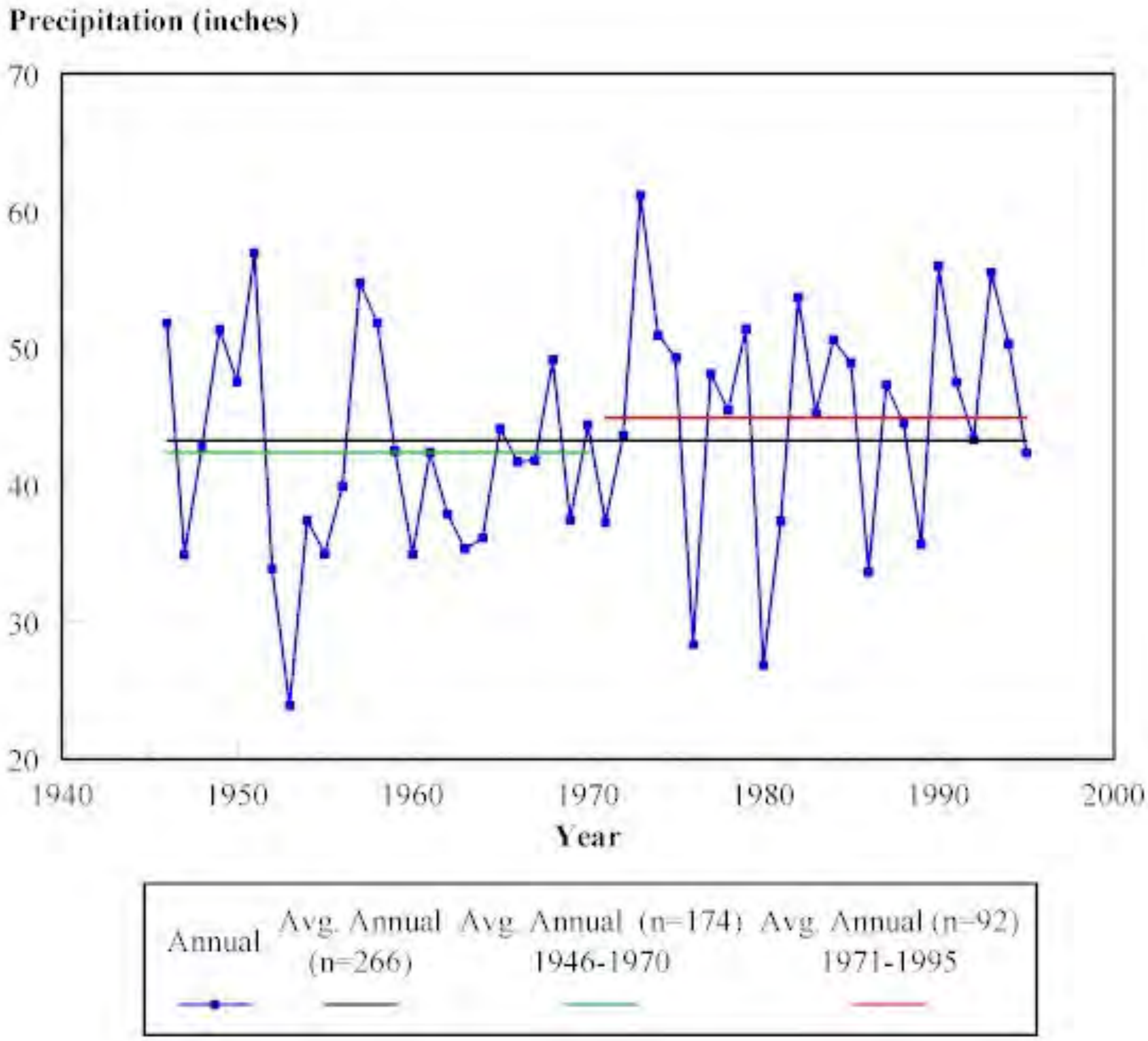


Figure Hy03. Average monthly precipitation amounts from National Weather Service and cooperative stations in and near the North Fork Watershed. (NCDC 1999).

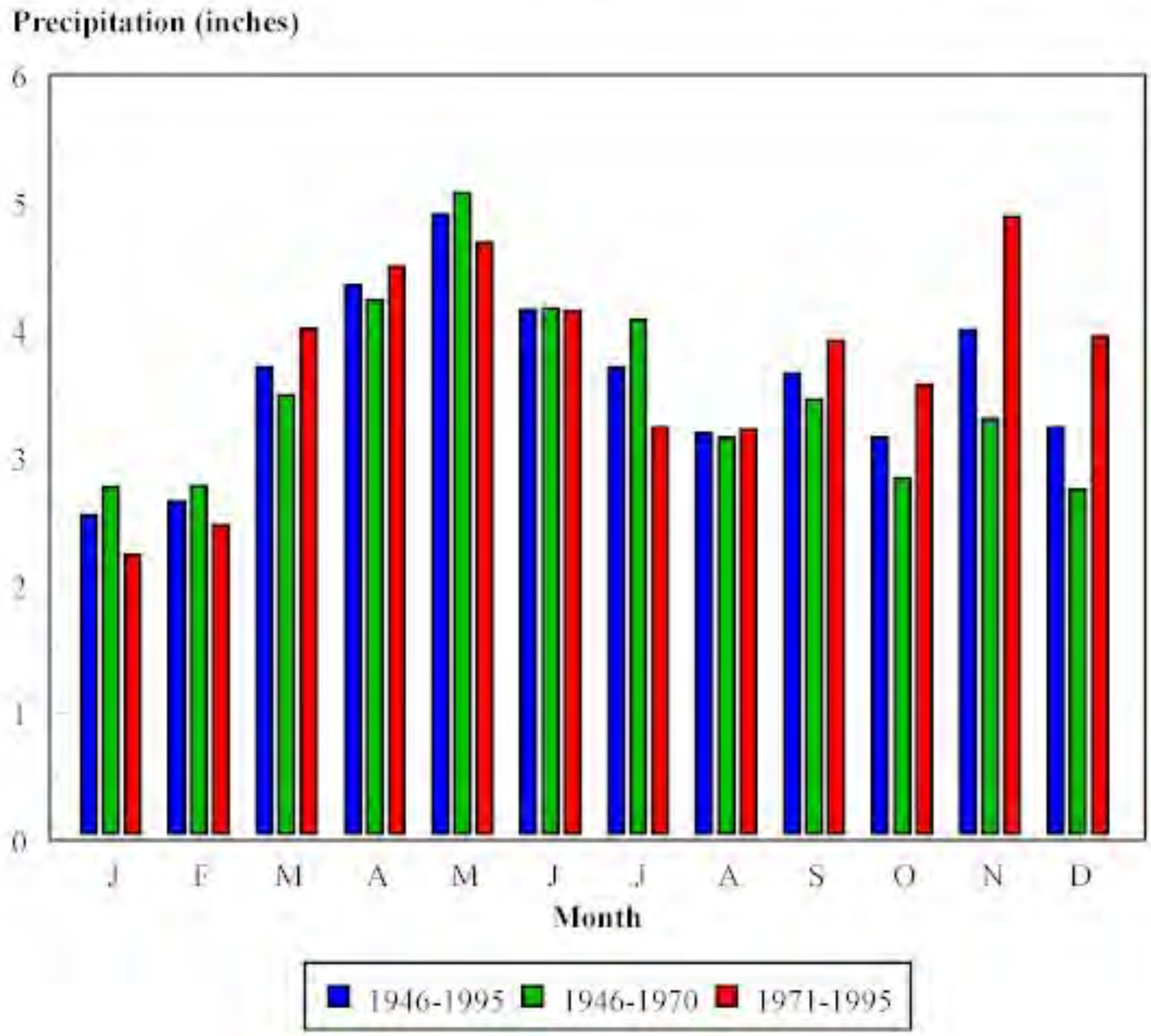


Figure Hy04. Change in mean daily flow as well as precipitation by month between two time periods (1945-1970 and 1971-1995).

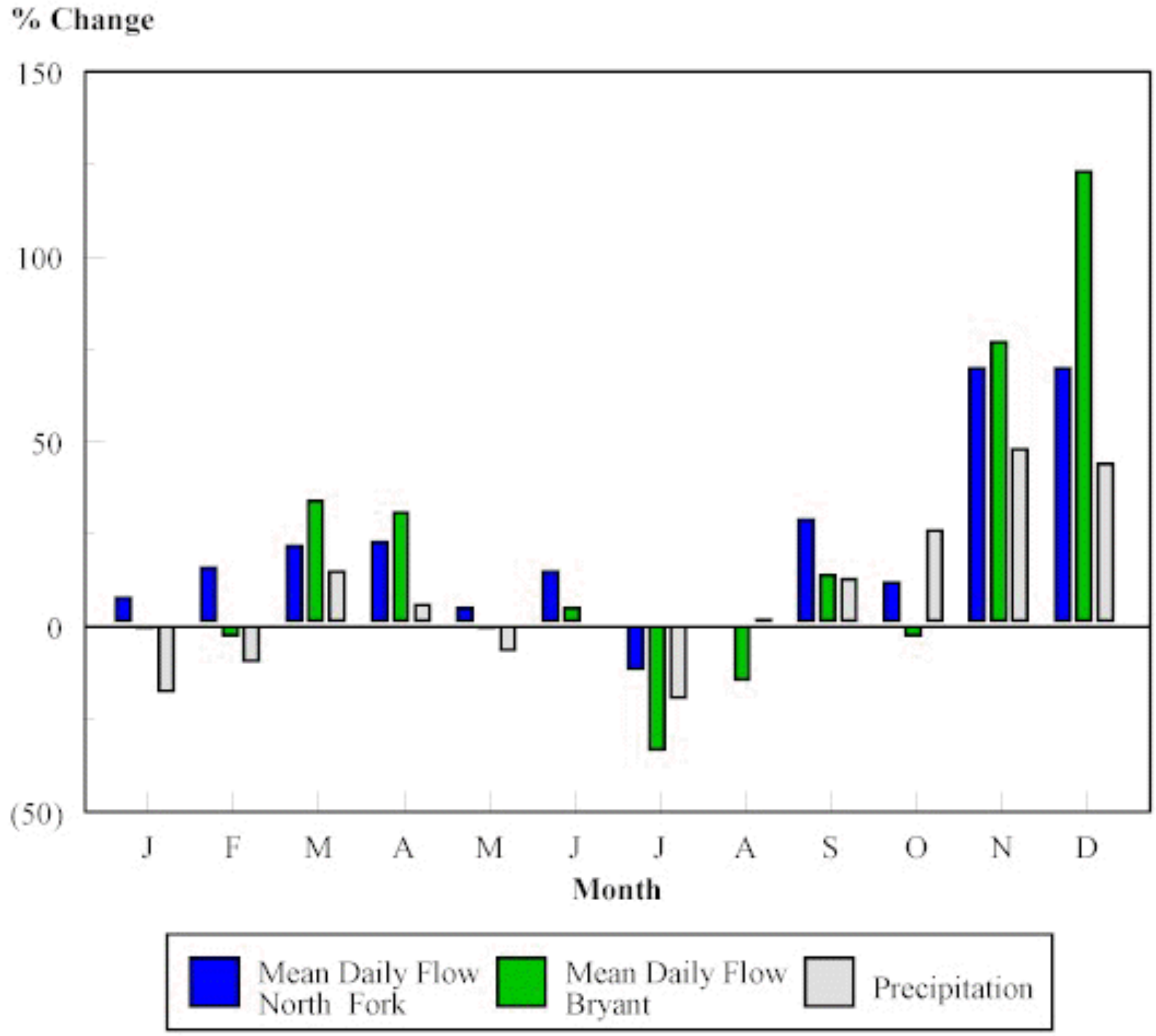


Figure Hy05. Average daily flow by month at USGS Gage Station 07057500 (North Fork River near Tecumseh, Missouri)

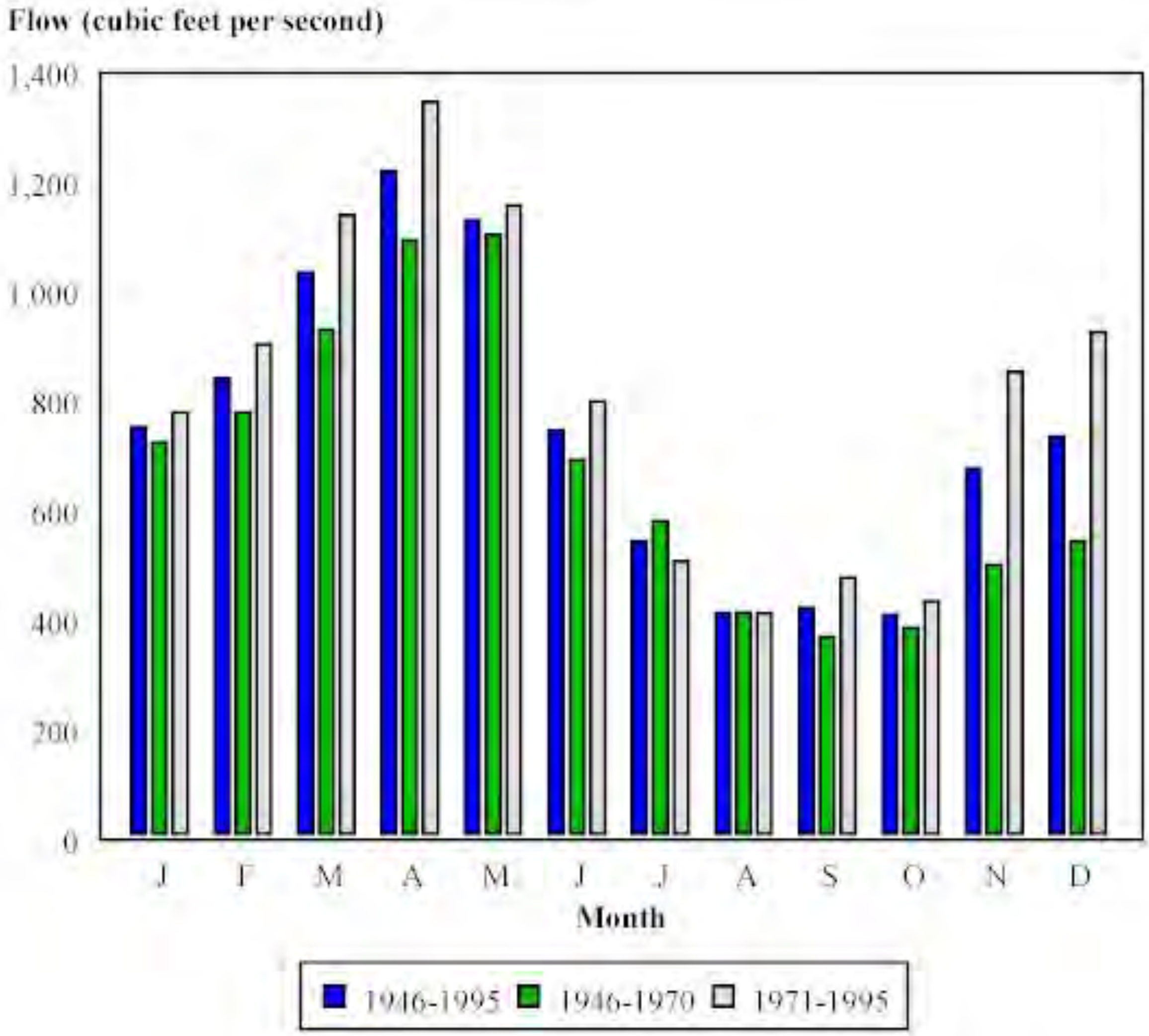


Figure Hy06. Average daily flow by month at USGS Gage Station 07058000 (Bryant Creek near Tecumseh, Missouri)

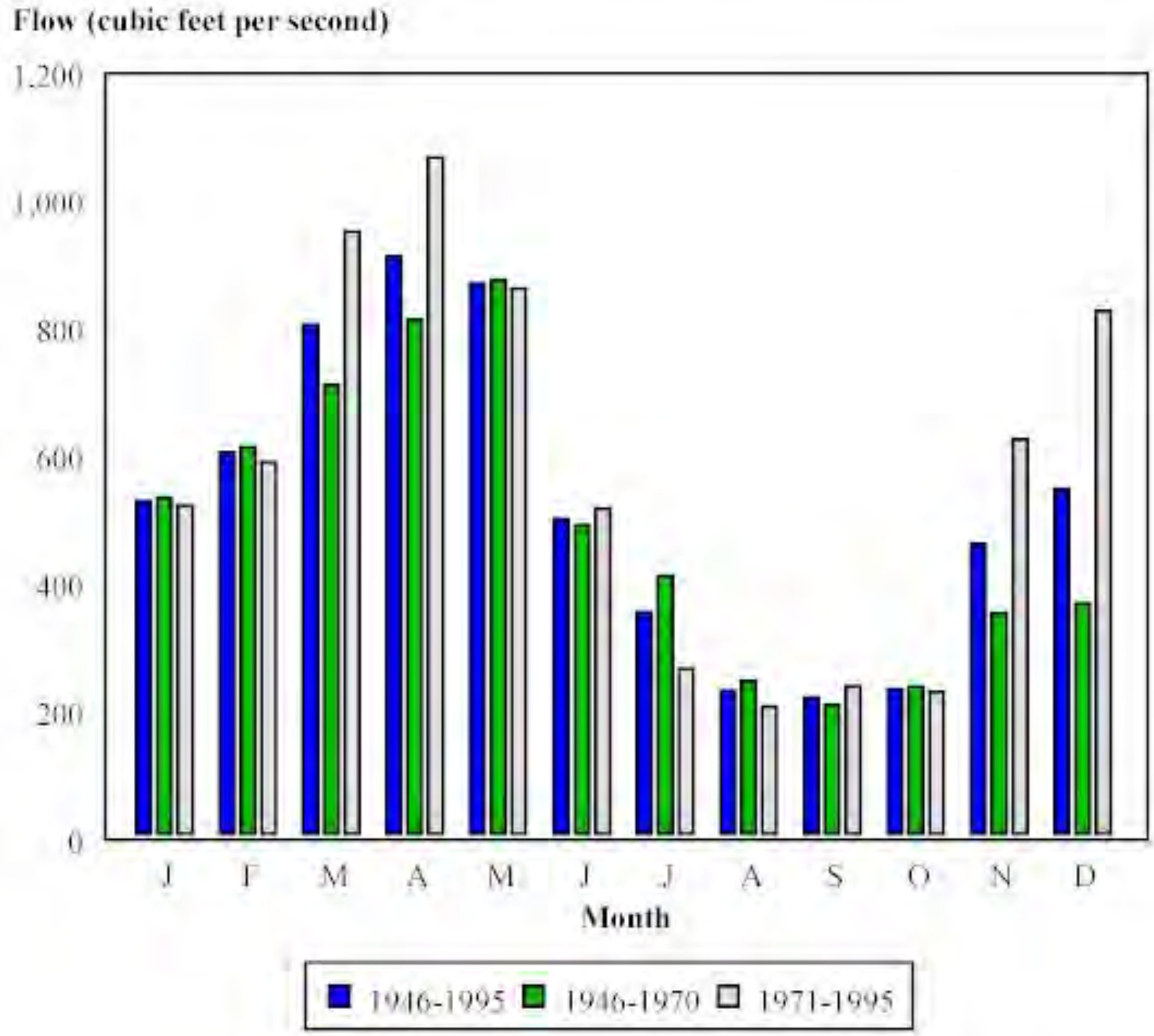


Figure Hy07. Flow duration changes between two time periods for Station 07057500 (North Fork near Tecumseh) (USGS 1999e).

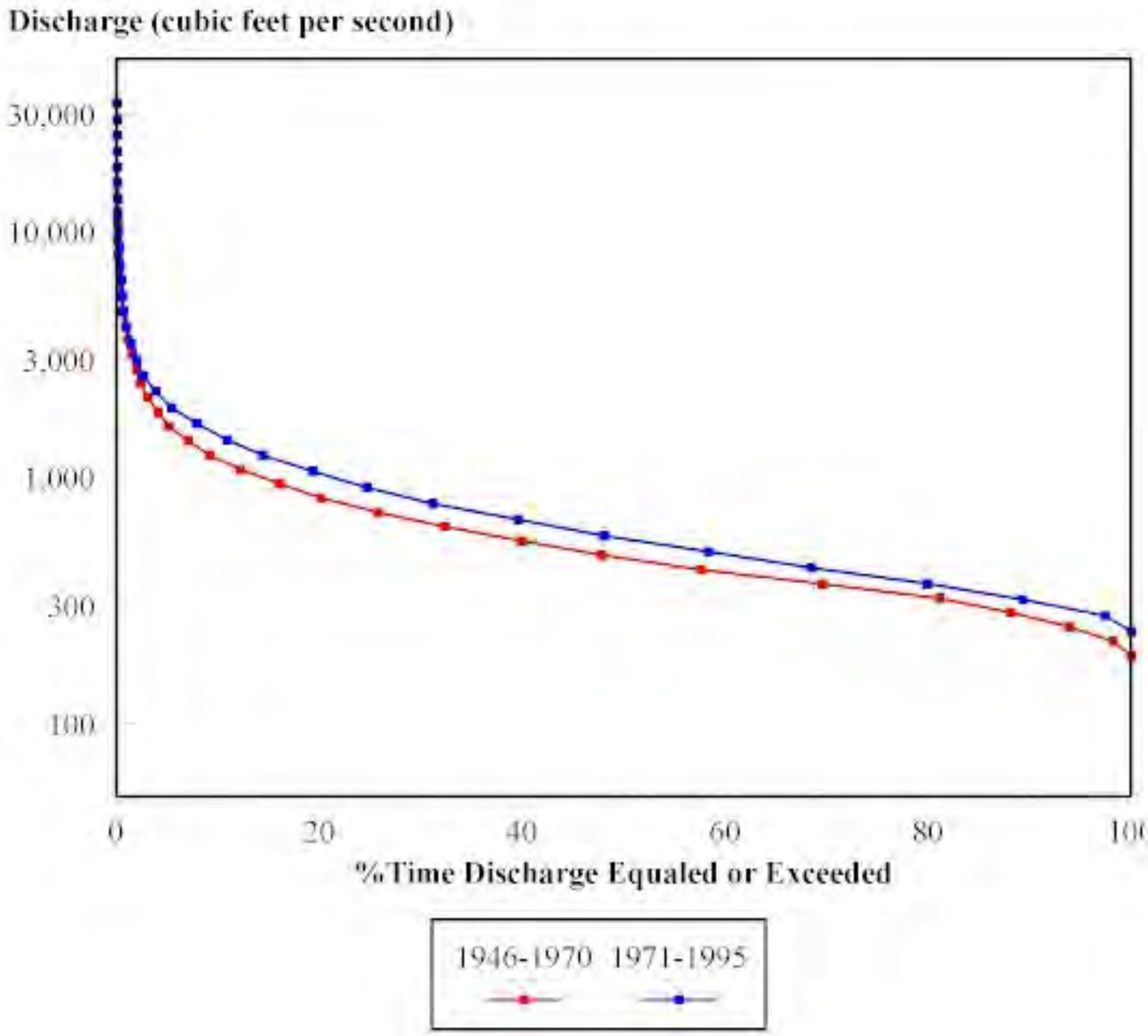


Figure Hy08. Flow duration changes between two time periods for Station 07058000 (Bryant Creek near Tecumseh) (USGS 1999e).

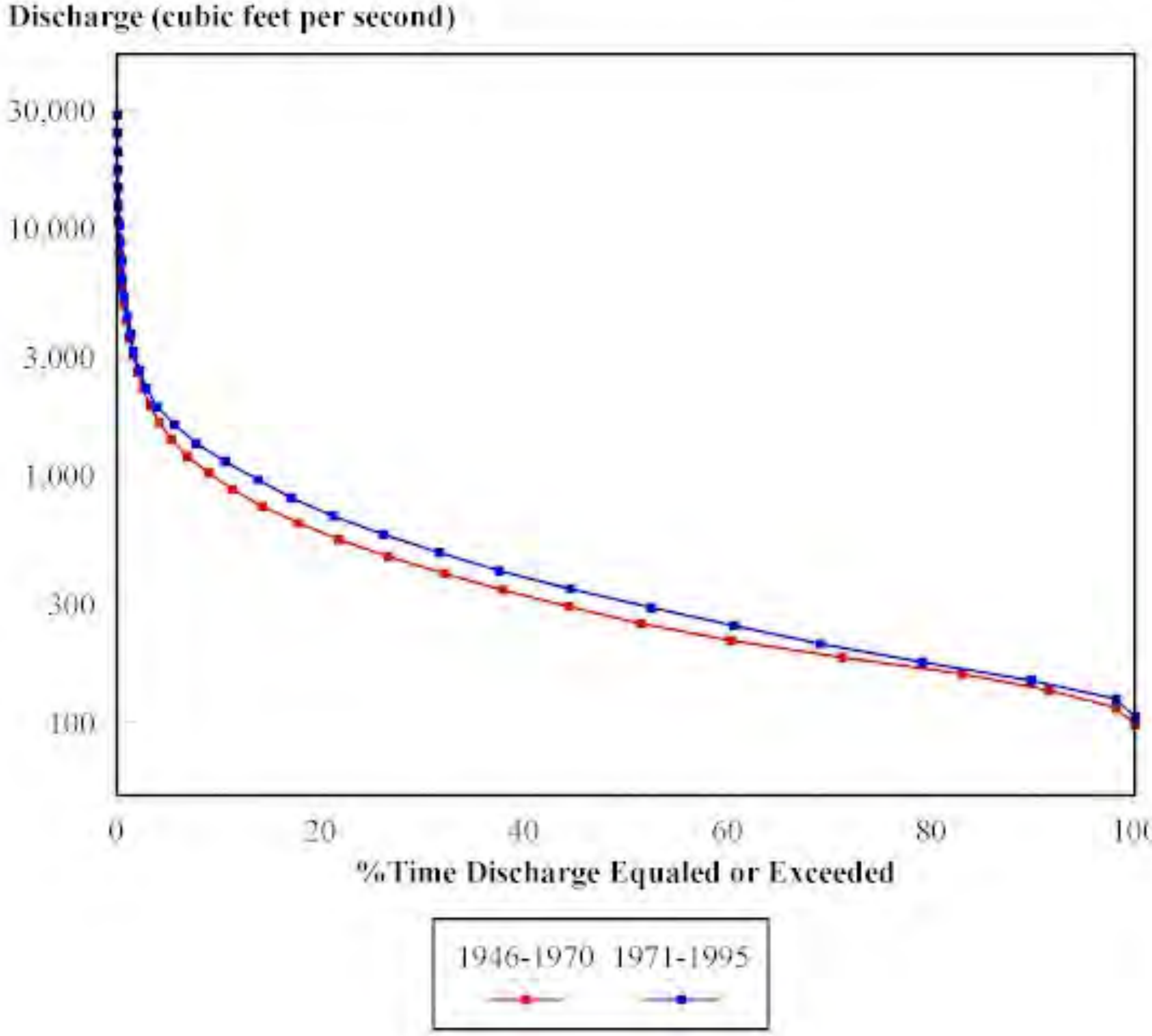


Figure Hy09. Comparison of flow duration for Station 07057500 (North Fork River near Tecumseh) and Station 07058000 (Bryant Creek near Tecumseh) (USGS1999e).

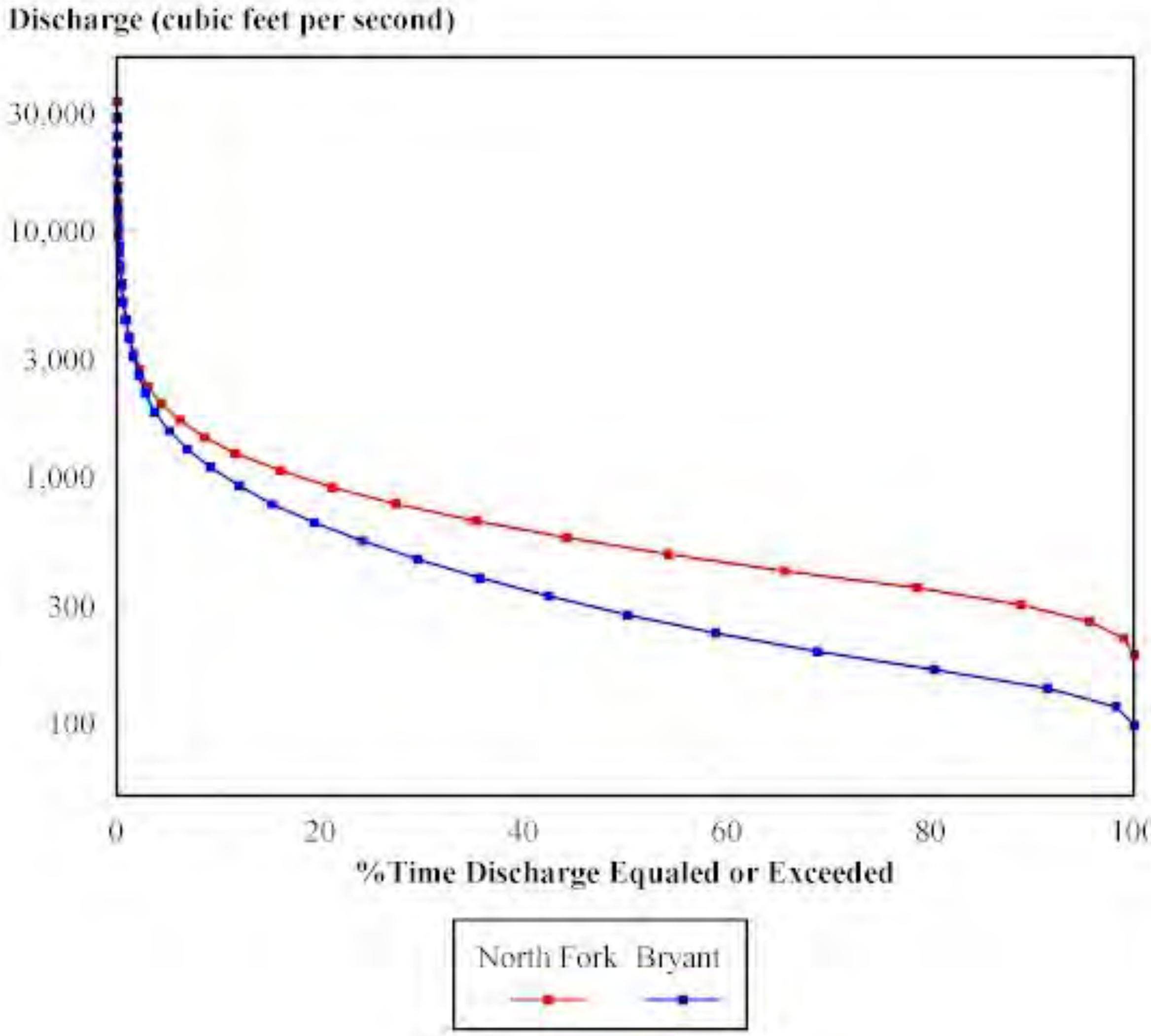


Table Hy01. Stations and other sites with significant flow and/or water quality data within the North Fork Watershed (MDNR 1994, USGS 1998a, and USGS 1999b).

| Station Number | Station Name | County | Period of Record |
|---|---|---|---|
| **7057350** | Tributary to Middle Indian Cr. near Cabool, MO. | Howell | 1985-1987 |
| **7057360** | Middle Indian Cr. near Cabool, MO. | Howell | 1985-1987 |
| **7057500** | North Fork River near Tecumseh, MO. | Ozark | 1944-1996 |
| **7057800** | Hodgson Mill Spring at Sycamore, MO. | Ozark | 1926, 1932, 1934, 1936, 1964-1972 |
| **7058000** | Bryant Creek near Tecumseh, MO. | Ozark | 1944-1985, 1994-1996 |
| **7058500** | North Fork River at Tecumseh, MO. | Ozark | 1921-1932, 1932-1944 |
| **7057475** | Double (Rainbow) Spring near Dora | Ozark | 1919, 1924-1925, 1934, 1936, 1942, 1964-1972 |
| **N/A** | North Fork River at Twin Bridges | Ozark | 1962-67 |
| **N/A** | Crystal Spring near Ava | Douglas | 1925, 1934, 1936, 1954, 1964, 1967-1968 |
| **N/A** | Blue Spring near Dora | Ozark | 1926, 1932, 1934, 1936, 1964, 1967-1968 |
| **N/A** | Bryant Creek near Evans | Douglas | 1964-1967, 1969. 1971 |
| **N/A** | Spring Creek at Twin Bridges | Ozark | 1962-1967 |
| **N/A** | Wilder Spirng near Elijah | Ozark | 1924-19251932, 1936, 1966-1967 |
| **N/A** | North Fork Spring near Dora | Ozark | 1964, 1966-1971 |
| **N/A** | Althea Spring near Tecumseh | Ozark | 1926, 1932, 1934, 1936, 1943, 1959, 1964, 1967-1968, 1971 |

Table Hy02. Highest and lowest instantaneous discharges and date of occurrence at the two operational gage stations within the North Fork River Watershed (USGS 1997 and 1999a).

| Station Number | Station Name | Period of Record | Instantaneous Peak Flow & Date | Instantaneous Low Flow & Date |
|---|---|---|---|---|
| **7057500** | North Fork R. near Tecumseh | 1944-1998 | 133,000 cfs 11/1985 | 187 cfs 9/1954 |
| **7058000** | Bryant Creek near Tecumseh | 1944-1985, 1994-1996 | 71,100 cfs 12/1982 | 96 cfs 9/1954 |

**cfs**=cubic feet per second.

Table Hy03. Magnitude of flood events (cubic feet per second) for selected recurrence intervals (years) at two sites in the North Fork Watershed (Alexander and Wilson 1995).

| Site | Recurrence Interval | | | | | | |
|---|---|---|---|---|---|---|---|
| | 2 | 5 | 10 | 25 | 60 | 100 | 500 |
| **North Fork R. at Tecumseh** | 11,700 | 23,300 | 33,400 | 50,800 | 67,300 | 87,200 | 150,000 |
| **Bryant Cr. At Tecumseh** | 11,600 | 21,100 | 28,400 | 38,400 | 46,400 | 54,700 | 75,200 |

# Water Quality

## Beneficial Use Attainment

Approximately 1026 reservoir acres and 272 stream miles within the North Fork Watershed have designated beneficial uses as defined in Tables G and H of the Rules of the Department of Natural Resources Division 20-Clean Water Commission Chapter 7-Water Quality (Table Wq01; MDNR 1996a). These streams and reservoirs must meet or exceed established criteria as defined in Table A of the Rules of the Department of Natural Resources Division 20-Clean Water Commission Chapter 7-Water Quality for those beneficial uses (MDNR 1999a). Noblett Lake is designated for livestock/wildlife watering, protection of aquatic life, and whole body contact recreation. Norfork Reservoir is designated for livestock/wildlife watering, protection of aquatic life, whole body contact recreation, and boating/canoeing. All watershed streams listed in Table H are designated for livestock/wildlife watering as well as protection of aquatic life. Several streams within the watershed have additional designated beneficial uses. These streams include The North Fork of the White River, Bryant Creek, Hunter Creek, Hurricane Creek, Lick Creek, and Spring Creek (Table Wq01). Approximately 22.0 miles of the North Fork of the White River is designated for irrigation, livestock/wildlife watering, protection of aquatic life, cold water fishery, whole body contact recreation, and boating/canoeing. Approximately 28.0 miles of the North Fork of the White River is designated for irrigation, livestock/wildlife watering, protection of aquatic life, cool water fishery, whole body contact recreation, and boating/canoeing (MDNR 1996a). In addition to the aforementioned designated uses, 46.5 stream miles within the North Fork Watershed have been designated as "Outstanding State Resource Waters" (Table Wq02) (MDNR 1996a). No streams within the North Fork Watershed are designated for use as a drinking water supply. The streams of this watershed have no public surface water withdrawals.

Section 303(d) of the federal Clean Water Law requires that states identify those waters for which current pollution control measures are inadequate (MDNR 1999a). This is accomplished by comparing data from those waters with water quality criteria established for designated beneficial uses of those waters (MDNR 1999b). Those waters are then included in the 303(d) list. The state must then conduct Total Maximum Daily Load (TMDL) studies on those waters in order to determine what pollution control measures are required and then insure those measures are implemented (MDNR 1999a). No streams or reservoirs within the watershed are included in the 1998 list (MDNR 1999c). The Clean Water Act requires that the list be updated every 2 years thus the next 303(d) list should be available in the year 2000 (MDNR 1999b).

## Chemical and Biological Water Quality

Data regarding the chemical and biological quality of stream flow within the North Fork Watershed has been collected by several different entities since the 1960s. The extensive amount of water quality data available for various parameters and varying time periods within the North Fork Watershed, makes an adequate summary of water quality data within this document, impractical.

In order to avoid going beyond the scope of this document by attempting to provide a comprehensive summary of all water quality data by all agencies for all available years, three stations within the North Fork Watershed have been selected in order to provide a spatial and temporal snapshot of selected water quality values. USGS stations 07057750 (Bryant Creek below Evans), 07057500 (North Fork River near Tecumseh), and 07057475 (Double Spring near Dora) have been selected for this purpose (Figure Wq01). Data for the years 1993-1997 were used to examine selected parameters at stations 07057750 and 07057475. Data for the years 1983-1987 were used to examine selected parameters at station 07057500. The differences in time periods analyzed are due to the differences in time periods with available water quality data.

Tables Wq03, Wq04, and Wq05 list selected water quality parameters and state standards as well as maximum and minimum observations of selected parameters from stations 07057500, 07057750, and 07057475 for respective periods of record. Observations at the previously mentioned stations consistently met water quality standards for the selected parameters during the years examined with the exception of fecal coliform bacteria (USGS 1994, 1995, 1996, 1997, 1998a, 1999a, 2001). The data indicates that all three stations periodically experienced fecal coliform levels exceeding standards for whole body contact recreation (200 colonies/100ml) (Figures Wq02, Wq03, and Wq04). Out of 31 observations conducted from 1994 to 1997, fecal coliform levels at Station 07057750 exceeded these standards twice. Both instances occurred during the month of April. Fecal coliform levels at station 07057500 exceeded state standards 7 out of 44 observations. All of these instances occurred during the recreational period, April 1-October 31 (as designated by MDNR 1996a). Levels at Station 07057475 exceeded these standards 6 times out of 24 observations from 1994 to 1997. Five of these instances occurred during the recreational period. Even though Double (Rainbow) Spring has not been designated for whole body contact recreation, its waters flow directly into a portion of the North Fork River which does have this designation. Water quality data also indicates that water at stations 07057750 and 07057475 (data not available for 07057500) is hard to very hard as defined by the USGS (1999f).

As stated previously, a large amount of water quality data for a variety of parameters and time periods is available for the North Fork Watershed. Two previously discussed stations (07057750 and 07057500) have been part of the ambient water quality monitoring network in Missouri http://missouri.usgs.gov/wtrqual/ambient.htm (USGS 2001). Water quality data is also available for additional parameters from the USGS Historical Water Quality Data Website http://wwwdmorll.er.usgs.gov/watdata/wtrqual/ and the annual USGS Water Resources Data Reports as well as the EPA Storage and Retrieval (STORET) Database http://www.epa.gov/storet/. In addition, volunteer water quality monitoring data is available from the Missouri Stream Team online database http://www.mostreamteam.org/vmsearch.html. Additional State Water Quality Standards are available in the most current document of the Rules of the Department of Natural Resources Division 20-Clean Water Commission Chapter 7-Water Quality http://mosl.sos.state.mo.us/csr/10csr/10c20-7a.pdf.

The United States Geological Survey conducted water quality samples within the North Fork Watershed from 1993-1995 as part of the Pesticides National Synthesis Project in order to determine the spatial and temporal distribution of contamination by pesticides in the water resources of the United States (USGS 1999g). The North Fork Watershed was part of the Ozark Plateau Study Unit of the National Water Quality Assessment Program. Two surface water and four ground water sampling sites were selected within the watershed (Figure Wq03) (USGS 1999h and 1999i). Ground water samples were only performed once at each site in 1993. However, surface water samples were taken in 1994 and 1995 (USGS 1999j and 1999k). Analysis of data from these samples indicate pesticide compounds were not detected in either surface water sample from 1994. However, pesticide compounds were detected in the 1995 samples at both sites with a maximum of 5 pesticide detections at one site (Table Wq06). Pesticide compounds were not detected in any of the four ground water samples. By Comparison, 39 of 43 surface water sites within the Ozark Plateaus Study Unit had detections of pesticides with 18 sites having samples with six or more pesticide detections (Bell et al. 1997). In addition, 73 of 215 ground water sample sites within the Ozark Plateaus Study Unit had pesticide detections with a maximum of 5 pesticides detected in any one sample (Adamski 1996).

Duchrow (1976) conducted water quality/aquatic invertebrate sampling at 6 sites on Bryant (2), Hunter Creeks (3), and Watered Hollow (1) in 1974-1975 (Figure Wq05) (Duchrow 1976). A total of 89 types of benthic invertebrates were collected in these samples. Water quality was evaluated by comparing calculated species diversity index values as well as the similarity of the benthic invertebrate communities at these sites to those criteria established for unpolluted Ozark streams. Invertebrate communities from these sites met or exceeded water quality criteria established for Ozark streams. Samples were conducted once again in 1976 at 2 sites on Hunter Creek in order to determine the impact, if any, of construction of

the Ava Landfill which became operational in 1975 (Duchrow 1977). Results from these samples indicated that the stream had not been adversely impacted since the opening of the Ava Landfill. Future benthic invertebrate sampling will need to be performed in this area as well as throughout the watershed in order to consistently monitor potential pollution problems.

## Ground Water Quality

Water quality tests performed by the Missouri State Public Health Laboratory in Springfield on 408 wells in Howell, Ozark, and Douglas Counties from July 1998 to August 1999 indicate that 138 (33.8%) well samples tested were unsafe. A well is considered unsafe if any coliform colonies result from the sample (Farmer, personal communication). Howell County had the highest percentage of unsafe wells with 40.9% of the wells tested in this group deemed as unsafe. It is important to note that other samples probably exist which are not included in these results. In addition, these results are inclusive of those portions of the counties mentioned which are outside the boundaries of the North Fork Watershed.

## Point Source Pollution

Table Wq07 lists 9 National Pollution Discharge Elimination System (NPDES) sites currently within the North Fork Watershed (Figure Wq03) (MDNR 1998a). The city of Norwood is the only permitted (by MDNR) municipal wastewater discharge within the watershed in Missouri (MDNR 1998a). As of 1997, the Norwood Waste Water Treatment Facility (WWTF) was discharging .030 million gallons per day (mgd) into a tributary of Dry Creek. This is believed to impact less than 0.1 miles of the receiving stream (MDNR 1994).

The Missouri Department of Natural Resources, Division of Geology and Land Survey has identified 23 active mines and 137 past producers within the North Fork Watershed in Missouri (MDNR 1998b). Of the 23 active mines, all are gravel removal operations or limestone quarries. The highest percentage of past producers are iron mines. Nearly all of these are surface mines which dot the watershed. These open pits can act as a direct link to the ground water system and thus pose a threat to ground water quality if pollutants are allowed to enter in. This can affect wells from which the watersheds population receives its water.

Land disruption from road and bridge construction as well as urban expansion often results in increased sediment loads to receiving water systems. Bridge construction also results in stream channel modification, which affects stream flow both up and down-stream from the bridge. Since 1995 there have been twenty-eight 404 permitted operations within the North Fork Watershed in Missouri. Eight of these involved bridge work or culvert work (Table Wq07) (USACOE 1999). According to the Missouri Department of Transportation Highway and Bridge Construction Schedule, there currently (1999) are no state highway projects involving bridge work scheduled within the watershed from 2000-2004 (MDT 1999).

Gravel mining also has the potential to threaten water quality within the watershed. Poor gravel mining practices can negatively impact water quality, riparian and aquatic habitats, and aquatic biota. Increased sedimentation and turbidity are a few problems associated with poor gravel mining practices. In 1998 there were 24 permitted operations within the North Fork Watershed (Figure Wq03) (USACOE 1998).

## Non-point Source Pollution

Perhaps one of the more difficult challenges to address within any watershed is non-point source pollution. Whereas point source pollution can usually be traced to a single discharge point or area such as a waste water treatment plant discharge, non point source pollution, such as sheet erosion of topsoil, runoff of nutrients from pastures, or pesticide or fertilizer runoff from a fields, is much more difficult to detect as well as remedy. It takes the cooperation of the landowners within a watershed to minimize

non-point source pollution and its impacts.

The greatest non-point threat in the North Fork Watershed is the potential contamination of the groundwater system. Seventy four percent of the water withdrawn within the watershed comes from the groundwater system. Domestic use is the single most prevalent use of this supply. In addition, much of the permanent flow within the watershed is enhanced by springs. Thus, any contaminant which affects groundwater quality is likely to affect surface water quality and vice versa. There are several ways in which contaminants can enter the groundwater system. These include losing streams, sinkholes, and abandoned wells. The potential for contamination by septic systems has been shown by Aley (1972 and 1974) to be increased in areas of soluble bedrock. (MDNR 1984). As indicated by dye traces performed within the watershed, ground water movement is not always restricted by surface watershed boundaries. Some groundwater does exhibit movement from other watersheds. The most notable example of this is groundwater movement from the Upper Gasconade Watershed to Hodgson Mill, Double (Rainbow) Spring, and North Fork Spring. Waste water from the Mansfield Waste Water Treatment Plant is discharged into a tributary of Fry Creek which, itself, is a tributary of Wolf Creek. As stated previously, water from both streams is lost to the ground water system and eventually emerges from Double, North Fork, and Hodgson Mill Springs. The North Fork River at Blue Springs and Double Spring (Rainbow Spring) changes from a clean substrate to a substrate which has an abundance of snails (MDNR 1984). The amount of filamentous algae also increases significantly. This condition continues for approximately 10 miles; indicating the influence of high nutrient loads from the spring flow.

A major contributor to the total organic waste within the North Fork Watershed is livestock waste (MDNR 1984). Livestock waste contributes to the Biological Oxygen Demand (BOD), suspended solids, fecal coliform, and fecal streptococci loads within streams. Table Wq08 lists the number of cattle and hogs within counties that intersect the watershed as well as percent of counties within the watershed.

Most cattle within the watershed are on pasture and in most instances, have direct access to streams. Results can include increased organics and bacterial loading, turbidity, and high concentrations of algae (MDNR 1984). The impact of livestock in streams is often more obvious than impacts from upstream point source discharges. In addition, cattle may cause soil compaction, as well as reduce stream bank and corridor vegetation which can lead to increased erosion and/or flood plain scour. "No discharge" lagoons or pits serving confined lots also pose a threat to streams in cases of accidental discharges (MDNR 1984). In 1984, there were 16 of these facilities within the North Fork Watershed.

## Water Pollution and Fish Kill Investigations

No chronic water pollution or fish kill areas are known within the North Fork Watershed. Table Wq10 lists eleven water pollution and/or fish kill investigations which have been conducted within the watershed since 1990 (MDC 1991-1995; MDNR 1999d; and MDC 1999a). Only one known fish kill has occurred within the watershed since 1990. The Missouri Department of Conservation has not performed toxicological sampling of fish from the North Fork Watershed.

## Water Use

Estimates of water use for the North Fork Watershed obtained from the United States Geological Survey National Water Use Database (1998b) indicate that total water withdrawn within the watershed in 1995 was 6.52 million gallons per day (mgd) (Table Wq11). Most of the water withdrawn in the watershed is from the groundwater system. All surface water withdrawn is for livestock or irrigation use. Water withdrawal for livestock was the most prevalent use within the North Fork Watershed in 1995 (USGS 1998b). Domestic use was the second most prevalent (Table Wq09).

Major water use information for the North Fork Watershed was obtained from the Missouri Department of Natural Resources (MDNR), Division of Geology and Land Survey. The MDNR maintains records of

"major" (those facilities capable of withdrawing 100,000 gallons/day) surface and ground water users throughout the state. Recent records (1997) indicate there were a total of six major water users, two of which were private surface water users with intakes on the North Fork River, Bryant Creek, Brush Creek, and Lick Creek (Table Wq12) (MDNR 1997). Surface water withdrawals for 1997 totaled approximately 156,480,000 gallons. The four major ground water users within the North Fork River Watershed included Fairview R-XI School, the City of Gainesville, Howell County Public Water Supply District #1 and a private entity. Ground water withdrawals by major water users in the watershed in 1997 totaled approximately 80,669,900 gallons.

## Recreational Use

In 1982, the North Fork of the White River was ranked with 36 other major watersheds in Missouri according to recreational value (MDC and MDNR 1982). Results were obtained by surveying professional staff from six state and federal agencies. The North Fork River recreation rank was 12th within the state. This value was expected to drop due to problems associated with intensive recreational use, bank and shoreline development, and poor land use. Remote location was also listed as a reason for a future drop in recreational importance.

Angler surveys are useful for evaluating angler use, species preference, and satisfaction. Angler surveys can also be used to identify changes or trends in angler responses over time. These surveys provide the information necessary for managers to meet angler needs, as well as improve and validate decisions to change or maintain regulations. Results from statewide annual angler surveys which were conducted by the Missouri Department of Conservation from 1983 to 1986 estimate that on an annual basis, 12,437 total days were spent angling on the North Fork River and its tributaries (MDC 1987). During the period of record, catfish were the most preferred species. On average, 3268 (26%) days were spent fishing for catfish, 2699 (22%) days for rainbow trout, and 2654 (21%)days for bass sp. per year.

Besides fishing the North Fork Watershed receives a large amount of other recreational use including floating. From May 29-August 8, 1999 canoe "put-ins" were counted at North Fork Recreation Area as part of a United States Forest Service (USFS) Study (Hyzer, personal communication and Dickens, personal communication). Counts were primarily done on weekends and usually ended around 12:00 p.m.-1:00 p.m. Data from these counts indicate an average of 163 canoe "put-ins" a day on the weekends during the previously mentioned time period. It is important to consider that the North Fork Recreation Area is just one of 11 public accesses within the watershed. Additional study will be needed in order to determine canoe use throughout the entire watershed.

Bank and shoreline development continues to occur in some areas on the major streams of the North Fork Watershed. Housing construction on the North Fork River down stream of the Mark Twain National Forest is one example. Problems associated with this type of development include destabilization of stream banks and flood plains due to vegetation removal which can then lead to increased sediment loads in streams, water quality impacts from poorly treated sewage, and loss of aesthetic value for recreational purposes.

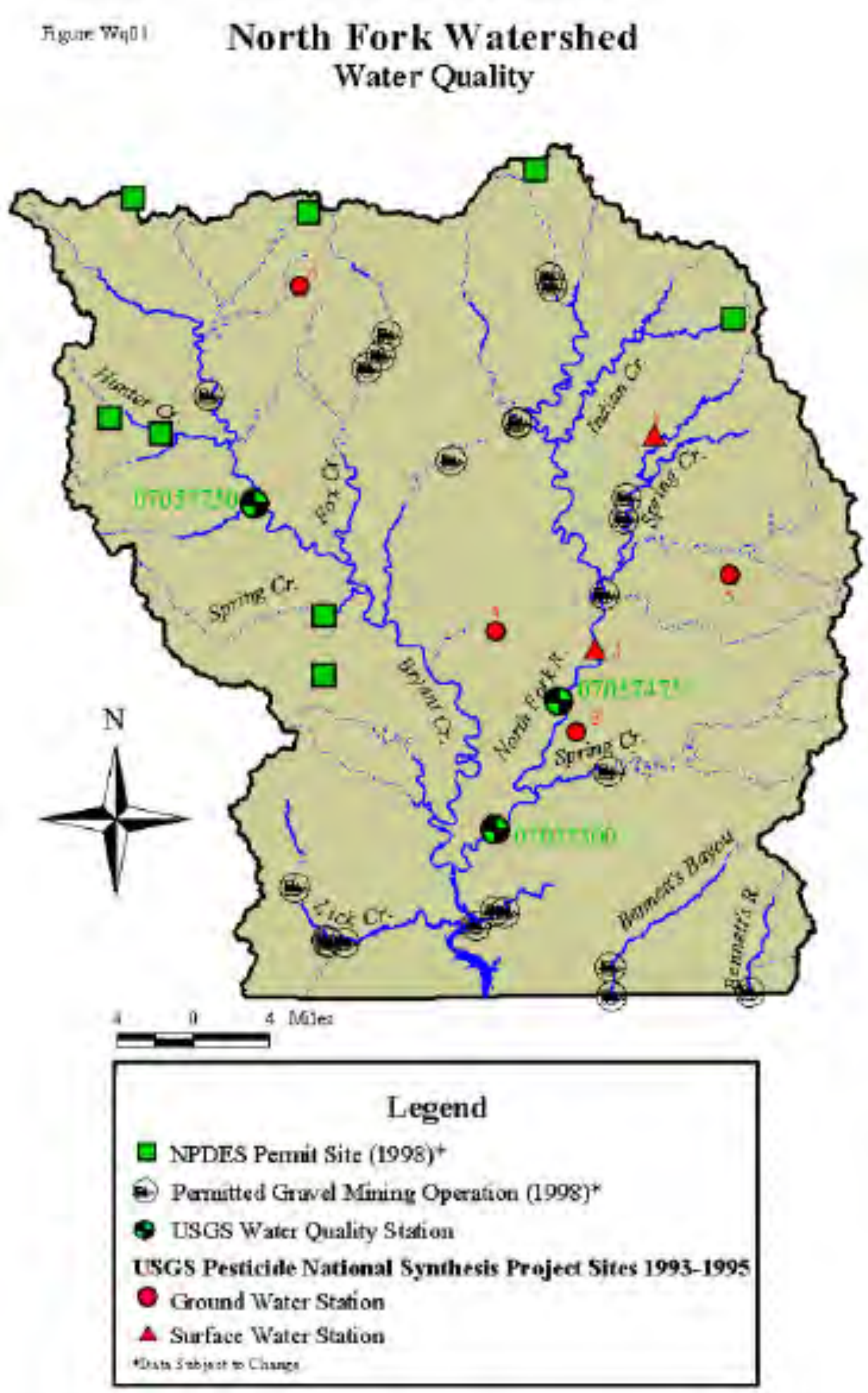
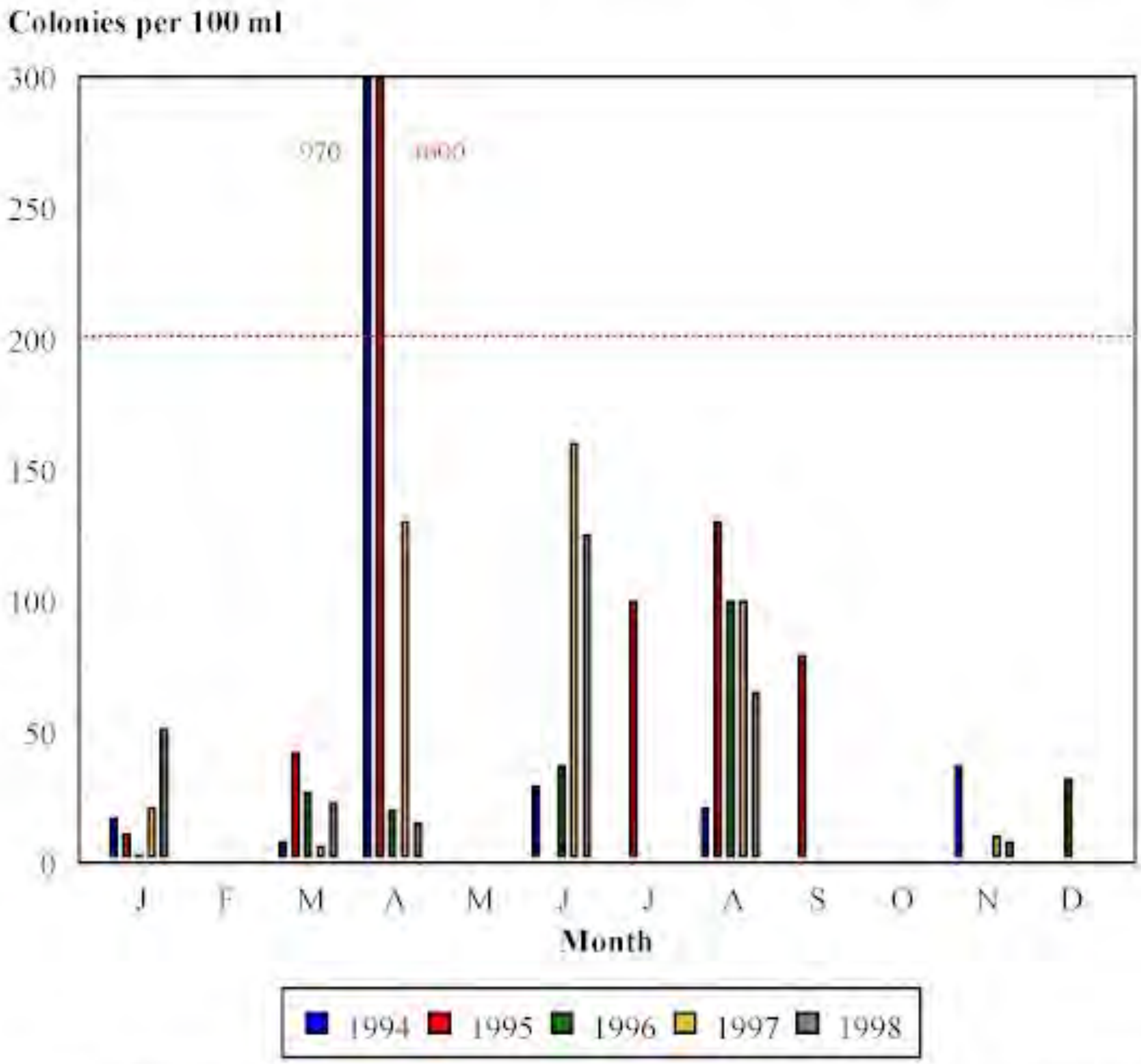


Figure Wq01
North Fork Watershed
Water Quality
Hunter Cr.
Fox Cr.
Indian Cr.
Spring Cr.
Spring Cr.
Bryant Cr.
North Fork R.
Spring Cr.
Lick Cr.
Bennett's Bayou
Bennett's R.
N
4 0 4 Miles
Legend
NPDES Permit Site (1998)*
Permitted Gravel Mining Operation (1998)*
USGS Water Quality Station
USGS Pesticide National Synthesis Project Sites 1993-1995
Ground Water Station
Surface Water Station
*Data Subject to Change

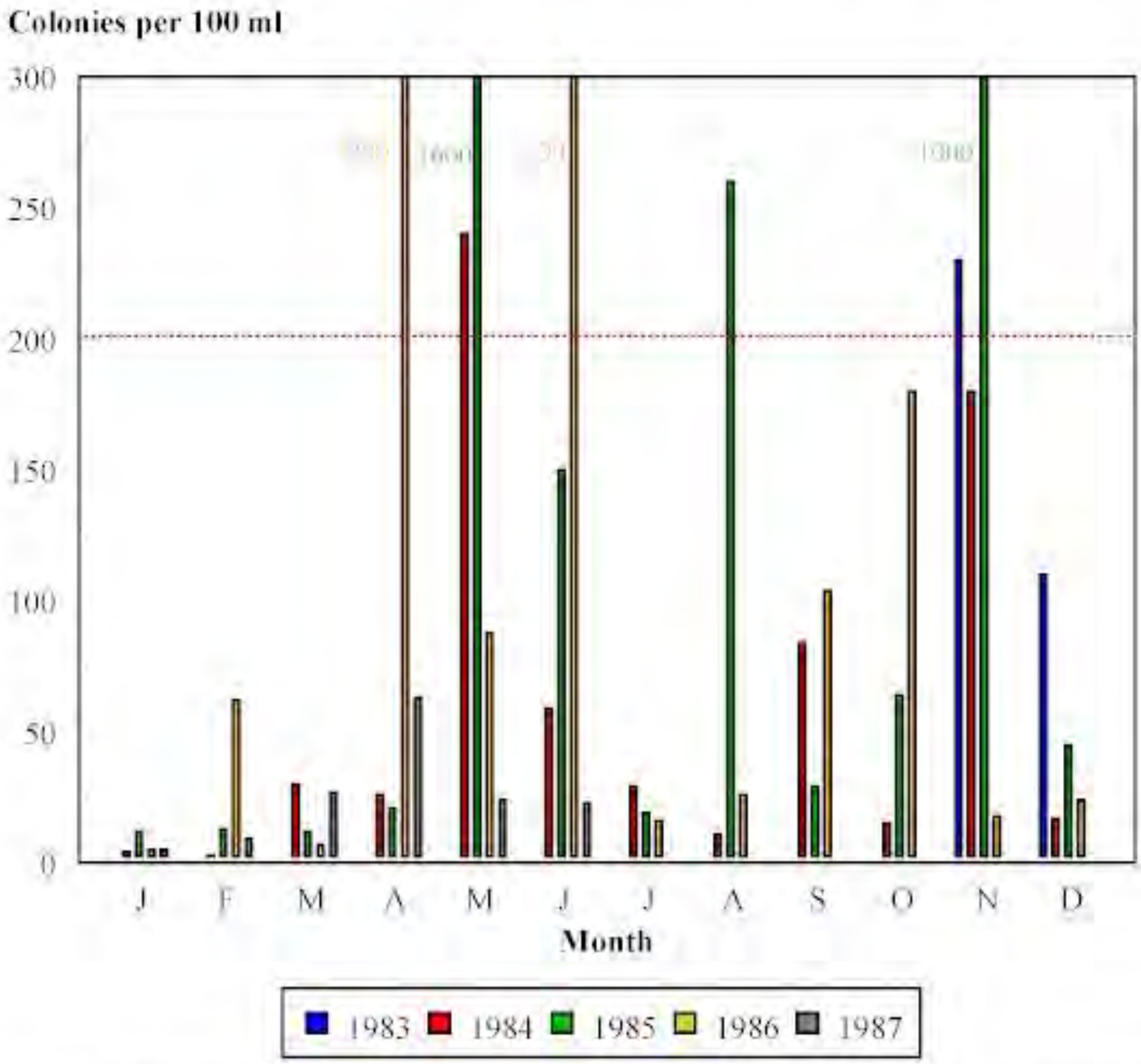
Figure Wq02. Fecal colliform colony counts per 100 milliliters at Station 07057750 (Bryant Creek Below Evens) (USGS 1995, 1996, 1997a, and 1998a).




Dashed red line represents limit in waters designated for whole body contact recreation from April 1-October 31 and any time for losing streams (MDNR 1996a).

Note: Data includes results based on colony count outside the acceptable range (non-ideal colony count). A non-ideal colony count refers to counts in which crowding and insufficient media (insufficient for full development of colonies) exist for an ideal colony count or the colony count is so low that its statistical validity is questionable (USGS 1997b).

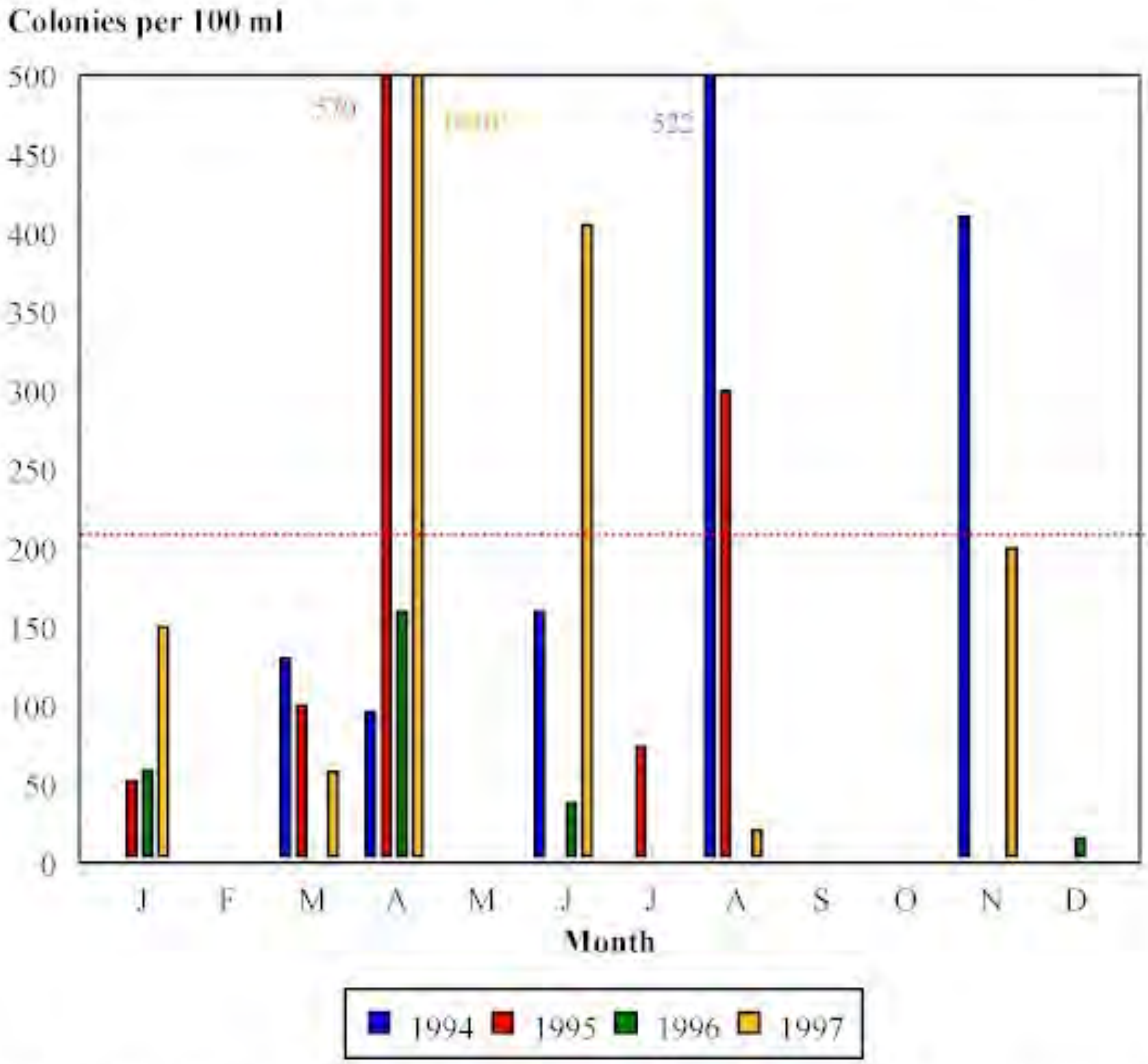
Figure Wq03. Fecal colliform colony counts per 100 milliliters at Station 07057500 (North Fork near Tecumseh) (USGS 1995, 1996, 1997a, and 1998a).




Dashed red line represents limit in waters designated for whole body contact recreation from April 1-October 31 and any time for losing streams (MDNR 1996a).

Note: Data includes results based on colony count outside the acceptable range (non-ideal colony count). A non-ideal colony count refers to counts in which crowding and insufficient media (insufficient for full development of colonies) exist for an ideal colony count or the colony count is so low that its statistical validity is questionable (USGS 1997b).

Figure Wq04. Fecal colliform colony counts per 100 milliliters at Station 07057475 (Double Spring near Dora, Missouri) (USGS 1995, 1996, 1997a, and 1998a).




Dashed red line represents limit in waters designated for whole body contact recreation from April 1-October 31 and any time for losing streams (MDNR 1996a).

Note. Data includes results based on colony count outside the acceptable range (non-ideal colony count). A non-ideal colony count refers to counts in which crowding and insufficient media (insufficient for full development of colonies) exist for an ideal colony count or the colony count is so low that its statistical validity is questionable (USGS 1997b).

Figure Wq 05

# North Fork Watershed

## Benthic Invertebrate/Water Quality Sampling Sites.

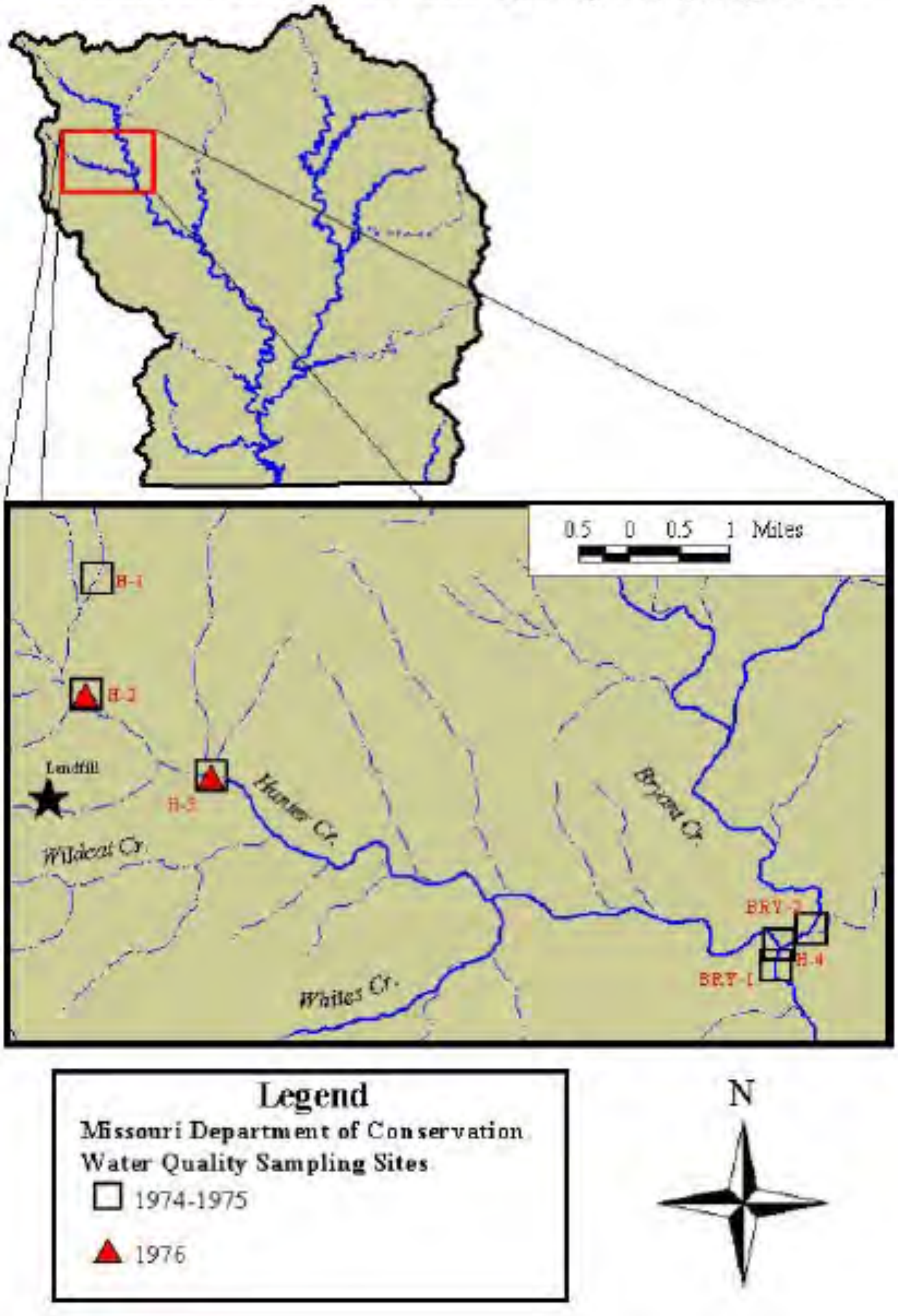


Table Wq01. Missouri Department of Natural Resources use designations for selected streams within the North Fork Watershed (MDNR 1996a). Locations are given in section, township, range format.

| Stream Name | Class[1] | Miles *acres | From | To | Designated Use* |
|---|---|---|---|---|---|
| **Noblett Lake** | L3 | 26* | 25,26n,11w | 25,26n,11w | lww,aql,wbc, |
| **Norfork Lake** | L2 | 1000* | 21n12w | 21n12w | lww,aql,wbc,btg |
| **Barren Cr.** | C | 4 | State Line | 08,21n,11w | lww,aql |
| **Bell Pond Hl.** | C | 1.5 | Mouth | 32,24n,11w | lww,aql |
| **Bennett's Bayou** | P | 6 | State Line | 30,22n,10w | lww,aql |
| **Bennett's Bayou** | C | 2 | 30,22n,10w | 16,22n,10w | lww,aql |
| **Bennett's R.** | C | 4 | State Line | 24,22n,10w | lww,aql |
| **Big Gulch** | C | 1.5 | Mouth | 08,27n,11w | lww,aql |
| **Blair Hl.** | C | 1 | Mouth | 01,22n,12w | lww,aql |
| **Bollinger Br.** | C | 4 | Mouth | 15,24n,12w | lww,aql |
| **Bridges Cr.** | C | 5 | Mouth | 17,22n,11w | lww,aql |
| **Brixey Cr.** | C | 2.5 | Mouth | 17,24n13w | lww,aql |
| **Brush Cr.** | P | 7 | Mouth | 11,25n,13w | lww,aql |
| **Brush Cr.** | C | 1.5 | 11,25n,13w | 01,25n,13w | lww,aql |
| **Bryant Cr.** | P | 13.5 | 05,22n,12w | 03,23n,12w | lww,aql,clf,wbc,btg |
| **Bryant Cr.** | P | 1 | 03,23n,12w | 34,24n,12w | lww,aql,cdf,wbc,btg |
| **Bryant Cr.** | P | 43 | 34,24n,12w | 17,27n,15w | lww,aql,clf,wbc,btg |
| **Trib. to Bryant** | C | 1.5 | Mouth | 14,24n,13w | lww,aql |
| **Caney Cr.** | C | 7 | Mouth | 05,23N,13W | lww,aql |
| **Clifty** | C | 11 | Mouth | 16,27n,12w | lww,aql |
| **Crooked Br.** | C | 1 | Mouth | 22,24n,11w | lww,aql |
| **Davis** | C | 4 | Mouth | 13,23n,10w | lww,aql |
| **Dicky Cr.** | C | 0.5 | Mouth | 14, 26n,15w | lww,aql |
| **Dry Cr.** | C | 15 | Mouth | 08,25n,09w | lww,aql |
| **Trib. Dry Cr.** | C | 2 | Mouth | 10,25n,09w | lww,aql |

| Stream Name | Class[1] | Miles *acres | From | To | Designated Use* |
|---|---|---|---|---|---|
| **Trib. Dry Cr.** | C | 4.5 | Mouth | 20,25n,09w | lww,aql |
| **Dry Cr.** | C | 1.5 | Mouth | 1,24n,13w | lww,aql |
| **Fox Cr.** | P | 4 | Mouth | 09,25n,13w | lww,aql |
| **Fox Cr.** | C | 5 | 09,25n,13w | 29,26n,13w | lww,aql |
| **Hagard Cr.** | C | 1.5 | Mouth | 01,22n,14w | lww,aql |
| **Hungry Cr.** | C | 0.5 | Mouth | 05,27n,11w | lww,aql |
| **Hunter Cr.** | P | 9 | Mouth | 06,26n,15w | lww,aql,wbc,btg |
| **Hurricane Cr.** | P | 1.5 | Mouth | 30,24n,12w | lww,aql,cdf |
| **Indian Cr.** | P | 10 | Mouth | 35,27n,11w | lww,aql |
| **Indian Cr.** | C | 7.5 | 35,27n,11w | 22,27n,10w | lww,aql |
| **L. Indian Cr.** | C | 2.5 | Mouth | 19,27n,10w | lww,aql |
| **Lick Br.** | C | 1.5 | Mouth | 02,24n,10w | lww,aql |
| **Lick Cr.** | P | 3 | Mouth | Hwy. J | lww,aql,wbc |
| **Lick Cr.** | P | 4.5 | Hwy J. | 19,22n,12w | lww,aql |
| **Lick Cr.** | C | 5 | 19,22n,13w | 30,23n,13w | lww,aql |
| **Liner Cr.** | C | 1 | Mouth | 09,21n,12w | lww,aql |
| **Little Cr.** | C | 5 | Mouth | 17,24n,15w | lww,aql |
| **Trib. To Little** | C | 1 | Mouth | 18,24n,15w | lww,aql |
| **Little Cr.** | C | 2 | Mouth | 36,22n,14w | lww,aql |
| **Lottie Cr.** | C | 0.5 | Mouth | 35,24n,12w | lww,aql |
| **Ludecker H1.** | C | 1.5 | Mouth | 04,23n,14w | lww,aql |
| **N. Bridges Cr.** | C | 3 | 17,22n,11w | 02,22n,11w | lww,aql |
| **N. Fk. Spring Cr.** | C | 1 | Mouth | 18,22n,14w | lww,aql |
| **Stream Name** | Class1 | Miles | From | To | Designated Use* |
| **N. Fk. White R.** | P | 22 | 03,22n,12w | 02,24n,12w | irr,lww,aql,cdf,wbc,btg |
| **N. Fk. White** | P | 28 | 34,25n,11w | 17,27n,11w | irr,lww,aql,clf,wbc,btg |

| Stream Name | Class[1] | Miles *acres | From | To | Designated Use* |
|---|---|---|---|---|---|
| **R.** | | | | | |
| **N. Fk. White R.** | C | 7 | 17,27n,11w | 23,28n,12w | lww,aql |
| **Trib. N. Fk. White R.** | C | 1 | Mouth | 34,23n,12w | lww,aql |
| **Nance Cr.** | C | 0.5 | Mouth | 15,24n,14w | lww,aql |
| **Noblett Cr.** | P | 2 | Mouth | Noblett L. Dam | lww,aql |
| **Noblett Cr.** | P | 4 | 24,26n,11w | 09,26n,10w | lww,aql |
| **Noblett Cr.** | C | 1 | 09,26n,10w | 10,26n,10w | lww,aql |
| **Panther Cr.** | C | 3.2 | Mouth | 18,28n,11w | lww,aql |
| **Pigeon Cr.** | C | 1 | State Line | 11,21n,13w | lww,aql |
| **Pine Cr.** | P | 1.5 | Mouth | 30,23n,12w | lww,aql |
| **Pine Cr.** | C | 9 | 30,23n,12w | 02,23n,13w | lww,aql |
| **Possum Walk Cr.** | C | 4 | Mouth | 10,21n,13w | lww,aql |
| **Prarie Cr.** | C | 3 | Mouth | 03,27n,15w | lww,aql |
| **Racoon Hl.** | C | 1 | Mouth | 16,24n,11w | lww,aql |
| | P | 4.5 | Mouth | 13,25n,15w | lww,aql |
| **Rippee Cr.** | C | 2 | 13,25n,15w | 14,25n,15w | lww,aql |
| **S. Bridges Cr** | C | 4 | 17,22n,11w | 13,22n,11w | lww,aql |
| **Sawmill HI.** | C | 2 | Mouth | 17,24n,11w | lww,aql |
| **Smith HI.** | C | 1 | Mouth | 30,23n,11w | lww,aql |
| **Spring Cr.** | P | 5 | Mouth | 14,23n,11w | lww,aql,btg |
| **Spring Cr.** | P | 7.5 | 14,23n,11w | 17,23n,10w | lww,aql,wbc,btg,ind |
| **Spring Cr.** | C | 8 | 17,23n,10w | 06,23n,09w | lww,aql |
| **Spring Cr.** | P | 16 | Mouth | 23,26n,10w | lww,aql,btg |
| **Spring Cr.** | C | 2 | 23,26n,10w | 12,26n,10w | lww,aql |
| **Trib. Spring Cr.** | C | 1.5 | Mouth | 13,26n,10w | lww,aql |
| **Spring Cr.** | P | 6 | Mouth | 06,24n,13w | lww,aql,btg |

| Stream Name | Class[1] | Miles *acres | From | To | Designated Use* |
|---|---|---|---|---|---|
| **Spring Cr.** | C | 5 | 06,24n,13w | 08,24n,13w | lww,aql |
| **Sweeten Cr.** | C | 1 | Mouth | 26,22n,13w | lww,aql |
| **Sweeten Hl.** | C | 4 | Mouth | 05,24n,11w | lww,aql |
| **Tabor Cr.** | P | 5 | Mouth | 09,24n,10w | lww,aql |
| **Tabor Cr.** | C | 2.5 | 09,24n,10w | 11,24n,10w | lww,aql |
| **Teeter Cr.** | C | 3 | Mouth | 20,25n,14w | lww,aql |
| **Trail Cr.** | C | 4 | Mouth | 03,24n,12w | lww,aql |
| **Turkey Cr.** | C | 1.5 | Mouth | 09,26n,15w | lww,aql |
| **Weidensaul Hl.** | C | 3 | Mouth | 27,23n,13w | lww,aql |
| **Trib. Weidensaul Hl.** | C | 1 | Mouth | 35,23n,13w | lww,aql |
| **Whites Cr.** | C | 3 | Mouth | 33,26n,15w | lww,aql |
| **Willow Cr.** | C | 2 | Mouth | 18,23n,10w | lww,aql |

**Note:** This table is not presented as a final authority.

***irr-**irrigation clf-cool water fishery

**lww-**livestock & wildlife watering cdf-cold water fishery

**aql-**protection of warm water aquatic life wbc-whole body contact recreation and human health-fish consumption. btg-boating & canoeing

**dws-**drinking water supply ind-industrial

**1L2-**Major reservoirs

**L3-**Other lakes which are waters of the state. For effluent regulation purposes, publicly owned lakes are those for which a substantial portion of the surrounding lands are publicly owned or managed.

**P-**Streams that maintain permanent flow even in drought periods.

**C-**Streams that may cease flow in dry periods but maintain permanent pools which support aquatic life.

Table Wq02. Stream reaches designated in Table E of the Rules of the Department of Natural Resources Division 20-Clean Water Commission Chapter 7-Water Quality (1996a) as "Outstanding State Resource Waters" within the North Fork Watershed.

| Stream Name | Miles | Location | County |
|---|---|---|---|
| **Bryant Creek** | 1.5 | Bryant Creek Natural Area in Rippee Conservation Area | Ozark/Douglas |
| **Indian Creek** | 17.5 | Mark Twain National Forest | Douglas/Howell |
| **North Fork of the White River** | 5.5 | Mark Twain National Forest | Ozark |
| **Noblett Creek** | 5 | Above Noblett Lake Mark Twain National Forest | Douglas/Howell |
| **Spring Creek** | 17 | Mark Twain National Forest | Douglas |

Table Wq03. Selected water quality data for gage station #07057750 (Bryant Creek near Evans) for water years 1994-1997 (USGS 1994, USGS 1995, USGS 1996, MDNR 1996a, USGS 1997, USGS 1998a). Note: This table is not a final authority.

| Parameter | State Standard | | | Measurement Min-Max |
|---|---|---|---|---|
| | I | V | VI | |
| **Temperature (°F) (cool water fishery)** | 84 Max | | | 36.5-80.6 |
| **pH** | —6.5-9.0— | | | 7.7-8.5 |
| **Oxygen, dissolved (mg/L) (cool water fishery)** | 5 Min | | | 7.0-16.8 |
| **Coliform, fecal (colonies / 100 ml)** | | | 200 | k2-4600 |
| **Streptococci, fecal (colonies / 100 ml)** | | | | k2-13,800 |
| **Alkalinity1 (mg/L as $CaCO^3$)** | | | | 112-229 |
| **Hardness (mg/L as $CaCO^3$)** | | | | 180-220 |
| **Total Ammonia (mg/l as $NH^3$)** | 0.1-32.12 | | | <0.010-0.096 |
| **Phosphorus, Total[3] (mg/L as P)** | | | | <0.02-0.09 |
| **Manganese, dissolved (ug/L as Mn)** | | | | <1.9-10.0 |
| **Fluoride, dissolved (mg/L as F)** | | | | <0.1 |
| **Iron, dissolved (ug/L as Fe)** | | | | <2-13 |

**I** Protection of aquatic life

**III** Drinking water supply

**V** Livestock and Wildlife Watering

**VI** Whole-body-contact recreation

**VII** Groundwater

**k** Non-ideal count of colonies (too large a sample, colonies merged)

[1] State standard for alkalinity currently unavailable. The Environmental Protection Agency currently recommends a minimum of 20.0 mg/L (USEPA 1999).

[2] Based on maximum chronic and acute standards for cold-water fishery. Levels are pH and temperature dependent. For specific criteria at varying pH and temperatures consult Table B of the Rules of the Department of Natural Resources Division 20-Clean Water Commission Chapter 7-Water Quality.

[3] State standard for phosphorus is currently unavailable. The Environmental Protection Agency currently recommends a maximum of 0.1mg/L for rivers (Christensen and Pope 1997).

Table Wq04. Selected water quality data for gage station #07057750 (North Fork River near Tecumseh) for water years 1994-1997 (USGS 1994, USGS 1995, USGS 1996, MDNR 1996a, USGS 1997, USGS 1998a). Note: This table is not a final authority.

| Parameter | State Standard | | | | Measurement Min-Max |
|---|---|---|---|---|---|
| | I | IV | V | VI | |
| **Temperature (°F) (cold water fishery)** | 68 Max | | | | 42.8-72.5 |
| **pH** | —6.5-9.0— | | | | 7.4-8.4 |
| **Oxygen, dissolved (mg/L) (cold water fishery)** | 6 Min | | | | 5.7-14.4 |
| **Coliform, fecal (colonies/100 ml)** | | | | 200 | 3.0-3200 |
| **Streptococci, fecal (colonies /100 ml)** | | | | | N/A |
| **Alkalinity1 (mg/L as $CaCO_3$)** | | | | | N/A |
| **Hardness (mg/L as $CaCO_3$)** | | | | | N/A |
| **Total Ammonia (mg/l as $NH_3$)** | 0.1-32.12 | | | | <0.01-0.07 |
| **Phosphorus, Total3 (mg/L as P)** | | | | | <1.0-13.0 |
| **Manganese, dissolved (ug/L as Mn)** | | | | | |
| **Fluoride, dissolved (mg/L as F)** | | | 4 | | <0.1 |
| **Iron, dissolved (ug/L as Fe)** | 1000 | | | | <3.0-60.0 |

**I** Protection of aquatic life

**IV** Irrigation

**V** Livestock and Wildlife Watering

**VI** Whole-body-contact recreation

**k** Non-ideal count of colonies (too large a sample, colonies merged)

**N/A** Not Available

[1]State standard for alkalinity currently unavailable. The Environmental Protection Agency currently recommends a minimum of 20.0 mg/L (USEPA 1999).

[2]Based on minimum chronic and acute standards for limited warm-water fishery. Levels are pH and temperature dependent. For specific criteria at varying pH and temperatures consult Table B of the Rules of the Department of Natural Resources Division 20-Clean Water Commission Chapter 7-Water Quality.

[3]State standard for phosphorus is currently unavailable. The Environmental Protection Agency currently recommends a maximum of 0.1mg/L for rivers (Christensen and Pope 1997).

Table Wq05. Selected water quality data for gage station #07057475 (Double Spring near Dora) for water years 1994-1997 (USGS 1994, USGS 1995, USGS 1996, MDNR 1996a, USGS 1997, USGS 1998a). Note: This table is not a final authority.

| Parameter | State Standard | | | | | Measurement Min-Max |
|---|---|---|---|---|---|---|
| | I | III | V | VI | VII | |
| **Temperture (°F) (cold water fishery)** | 68 Max | | | | | 51.8-57.2 |
| **pH** | —6.5-9.0— | | | | | 6.7-7.6 |
| **Oxygen, dissolved (mg/L) (cold water fishery)** | 6 Min | | | | | 6.7-11.5 |
| **Coliform, fecal (colonies/100 ml)** | | | | 200 | | k1-k1010 |
| **Streptococci, fecal (colonies/100 ml)** | | | | | | k1-k1100 |
| **Alkalinity[1] (mg/L as $CaCO_3$)** | | | | | | 128-240 |
| **Hardness (mg/L as $CaCO_3$)** | | | | | | 140-210 |
| **Total Ammonia (mg/l as $NH_3$)** | 0.1-32.12 | | | | | <0.010-0.036 |
| **Phosphorus, Total[3] (mg/L as P)** | | | | | | <0.02-0.09 |
| **Manganese, dissolved (ug/L as Mn)** | | | | | | 50 50 <1-2 |
| **Flouride, dissolved (mg/L as F)** | | 4 | 4 | 4 | 4 | <0.1 |
| **Iron, dissolved (ug/L as Fe)** | 1000 | 300 | | | 300 | <1.0-14 |

**I** Protection of aquatic life

**III** Drinking water supply

**V** Livestock and Wildlife Watering VI Whole-body-contact recreation VII Groundwater

**k** Non-ideal count of colonies (too large a sample, colonies merged)

[1]State standard for alkalinity currently unavailable. The Environmental Protection Agency currently recommends a minimum of 20.0 mg/L (USEPA 1999).

[2]Based on maximum chronic and acute standards for cold-water fishery. Levels are pH and temperature dependent. For specific criteria at varying pH and temperatures consult Table B of the Rules of the Department of Natural Resources Division 20-Clean Water Commission Chapter 7-Water Quality.

[3]State standard for phosphorus is currently unavailable. The Environmental Protection Agency currently recommends a maximum of 0.1mg/L for rivers (Christensen and Pope 1997).

Table Wq06. Results of Pesticides National Synthesis Project water quality sampling for pesticide compounds within the North Fork Watershed (USGS 1999i and 1999j).

| Station | Type | Pesticide Compound Detected |
|---|---|---|
| **1** | Surface | Atrazine; cis-Permithrin; Dieldrin; p,p'-DDE |
| **2** | Surface | Atrazine; Deethylatrazine; Metolachlor; p,p'-DDE; Thiobencarb |
| **3** | Ground Water | Non Detection |
| **4** | Ground Water | Non Detection |
| **5** | Ground Water | Non Detection |
| **6** | Ground Water | Non Detection |

Table Wq07. NPDES permit sites within the North Fork Watershed in Missouri (MDNR 1998a).

| Facility Name | Recieving Stream | Facility Type | County |
|---|---|---|---|
| **Crystal Lake Fisheries** | Hunter Cr. | Hatchery | Douglas |
| **Ava Landfill** | Trib. Hunter Cr. | Land Fill | Douglas |
| **Journagan-Wllow Springs** | Trib. Indian Cr. | Limestone Quarry | Howell |
| **Red Dot Farm** | Brixey Cr. | Animal Waste | Ozark |
| **Rainbow Trout Ranch** | Spring Cr. | Trout Hatchery | Ozark |
| **Rainbow Trout Ranch** | Spring Cr. | Motel | Ozark |
| **Leo Journagan Const.** | Trib North Fork R. | Limestone Quarry | Texas |
| **Assoc. Milk Prod. Inc.** | Trib. Bryant Cr. | Food | Wright |
| **Norwood WWTP** | Trib. Dry Cr. | Waste Water Treatment Plant | Wright |

**Note:** This table is not a final authority. Data subject to change.

Table Wq08. Operations within the North Fork Watershed having 404 permits since 1995 (USACOE 1999).

| Stream Name | Work Type | Permit Date | |
|---|---|---|---|
| **- Culvert Construction** | | 11-Oct-95 | |
| **- Utility Line** | | 3-Feb-95 | |
| **Bryant Cr.** | Bank Stabilization | 29-May-97 | 250 |
| **Bryant Cr.** | Bank Stabilization | 29-May-97 | 80 |
| **Bryant Cr.** | Bank Stabilization | 29-Apr-97 | |
| **Bryant Cr.** | Gravel Removal | 23-Feb-96 | |
| **Clifty Cr.** | Gravel Removal | 26-Mar-98 | |
| **Clifty Cr.** | Gravel Removal | 6-Apr-98 | |
| **Dry Cr.** | None Given | 1-Mar-95 | |
| **E. Prong Fox Cr.** | Culverts | 23-Oct-97 | 45 |
| **Fox Cr.** | Gravel Removal | 25-Mar-98 | |
| **Fox Cr.** | Gravel Removal | 8-Apr-98 | |
| **Fox Cr.** | Gravel Removal | 3-May-95 | |
| **Hunter Cr.** | Bridge Repair | 8-May-97 | 100 |
| **Lick Cr.** | Sand/Gravel Removal | 10-Dec-97 | |
| **Lick Cr.** | Sand/Gravel Removal | 6-May-97 | |
| **Lick Cr.** | None Given | 30-Sep-96 | |
| **North Fork R.** | Gravel Removal | 2-Oct-96 | |
| **North Fork R./ Indian Cr.** | Gravel Removal | 22-Mar-95 | |
| **North Fork R.** | Gravel Removal | 14-Jul-95 | |
| **North Fork R.** | Bridge Replacement | 25-Nov-98 | 40 |

**Note:** This table is not presented as a final authority. Status of permits subject to change.

Table Wq07. Operations within the North Fork Watershed having 404 permits since (continued) 1995 (USACOE 1999).

| Stream Name | Work Type | Permit Date | Linear Feet Affected |
|---|---|---|---|
| **North Fork R.** | Bridge Repair | 28-Apr-97 | |
| **North Fork R.** | Bridge Construction | 27-Nov-98 | 40 |
| **Prairie Hl.** | Bridge | 29-Jun-95 | |
| **Prairie Hl.** | Bridge | 15-Sep-95 | |
| **Spring Cr.** | Gravel Removal | 13-Nov-97 | |
| **Spring Cr.** | Boat Ramp | 5-May-95 | |
| **Spring Cr.** | Boat Ramp | 23-May-96 | |

**Note:** This table is not presented as a final authority. Status of permits subject to change.

Wq09. 1997 Livestock numbers for counties intersected by the North Fork Watershed (MASS 1999). State ranking (of 114 counties) is given in parentheses.

| County | % of County in Watershed | Cattle | Hogs |
|---|---|---|---|
| **Douglas** | 66.70% | 63,500 (16) | 1,200 (100) |
| **Howell** | 35.00% | 95,500 (4) | 10,000 (62) |
| **Ozark** | 56.80% | 57,000 (24) | 4,000 (83) |
| **Texas** | 3.10% | 102,000 (3) | 2,100 (91) |
| **Webster** | <1% | 75,000 (10) | 24,000 (33) |
| **Wright** | 8.10% | 78,000 (8) | 6,000 (75) |

Table Wq10. Fish kill and water pollution investigations conducted within North Fork Watershed from 1990-1998 (MDC 1991-1995; MDNR 1999d; and MDC 1999a).

| Date | Stream | Facility Ownership | Fish Kill | Description |
|---|---|---|---|---|
| **4/1/90** | Trib. to Brush Cr. | Private | No | Animal waste solids in stream. |
| **7/93, 8/94** | Trib. to Fox Cr. | Private | No | Solids in Spring Branch. |
| **Apr-92** | Trib. to S. Bridges Cr. | Private | No | Turbidity, manure solids deposited in spring branch. |
| **Jul-93** | Fox Cr. | Private | No | Septic tank effluent surfacing, discharges to spring. |
| **8/29/94** | Brixey Cr. | Private | Yes | Agricultural: hog manure. |
| **11/14/94** | North Fork R. | N/A | No | Transportation: brewers grain. |
| **4/91, 11/93, Apr-95** | Trib. Dry Cr. | Municipal | No | Bloodworms, excess algae, poor Bloodworms, excess algae, poor |
| **5/28/98** | North Fork R. | N/A | No | Excessive turbidity and Sedimentation. |

Table Wq11. Water use within the North Fork Watershed in 1995 based on withdrawals in millions of gallons per day (USGS 1998b).

| Use | Ground Water | Surface Water | Total |
|---|---|---|---|
| **Public Supply (Total)** | 3.41 | - | 3.41 |
| **Domestic (delivered)** | - | - | 0.62 |
| **Commercial (delivered)** | - | - | 0.14 |
| **Industrial (delivered)** | - | - | 0.6 |
| **Self-Supplied (Total)** | 1.38 | 1.71 | 3.11 |
| **Domestic** | 0.89 | - | 0.89 |
| **Commercial** | 0.01 | - | 0.01 |
| **Industrial** | 0.02 | - | 0.02 |
| **Livestock** | 0.45 | 1.31 | 1.76 |
| **Irrigation** | 0.03 | 0.4 | 0.43 |
| **Total** | 4.81 | 1.71 | 6.52 |

Table Wq12. Major water users within the North Fork Watershed (MDNR 1997).

| Owner | Source | No.of Intakes | Total Gallons Pumped in 1997 | Acres Irrigated |
|---|---|---|---|---|
| **Fairview R-XI School** | Ground Water | 1 | 1,252,800 | 0 |
| **City of Gainesville** | Ground Water | 4 | 52,632,300 | 0 |
| **Pwsd #1 Howell Co** | Ground Water | 1 | 25,816,500 | 0 |
| **Private** | Lick Creek | 2 | 60,480,000 | 140 |
| | North Fork River | 2 | 96,000,000 | 110 |
| **Private** | Ground Water | 1 | 968,300 | 0 |
| **Private** | Bryant Creek | 2 | 0 | 0 |
| | Brush Creek | 2 | 0 | 0 |
| **Total** | - | 15 | 237,149,900 | 250 |

# Habitat Conditions

## Dam and Hydropower Influences

One water control structure, Dawt Mill Dam, is located on the mainstem of the North Fork River in Missouri. The dam is a low dam (less than 10 feet high) and is located 1.8 miles above Tecumseh. The original Dawt Mill Dam was constructed in late 1800s in order to supply power to the machinery of Dawt Mill (Cochran 1980 and Robins 1991d). Both the dam and mill were replaced shortly after the turn of the century. The dam was rebuilt again in the 1970s after flood debris severely damaged the dam (Cochran 1980). Other water control structures within the watershed in Missouri include Noblett Lake Dam (Noblett Creek), Rockbridge Dam (Spring Creek), and Althea Spring Dam (Althea Spring Branch). All were constructed prior to 1940. Figure Hc01 displays the location of the previously mentioned water control structures.

The North Fork River flows into Norfork Lake which has a recognized beginning at the confluence of Bryant Creek. Norfork Lake Dam was completed in 1944 and is located 4.8 river miles upstream from the confluence of the North Fork with the White River near Norfork, Arkansas (USACOE 1993).

Norfork Lake Dam impounds 1,983,000 acre feet of water with a surface area of 30,700 acres at top of flood control pool.

## Channel Alterations

There have been no significant channel alterations anywhere throughout the North Fork Watershed. Small channelization projects have probably occurred on private property and also from road and bridge construction. However, these activities currently are not considered to be a major threat to the river system. Currently (1999) there are no planned state transportation projects involving bridge construction within the watershed from 1999-2004(MDT 1999).

In 1998 there were 24 permitted gravel removal operations within the watershed (Figure Wq06) (USACOE 1998). The negative impacts of gravel mining have been shown to include channel deepening, sedimentation of downstream habitats, accelerated bank erosion, the formation of a wider and shallower channel, the lowering of the floodplain water table, and channel shift (Roell 1999).

## Natural Features

Between 1987 and 1991 the Missouri Department of Conservation inventoried counties within the North Fork Watershed for unique natural features (Smith 1990; Ryan and Smith 1991). The inventories recognized seven categories of natural features: examples of undisturbed natural communities, habitat of rare or endangered species, habitat of relict species, outstanding geological formations, areas for nature studies, other unique features, and special aquatic areas having good water quality, flora, and fauna.

These studies identified 177 potential natural features in the North Fork Watershed. Of the 177 sites, 124 had exceptional or highly significant natural features. The North Fork River and Bryant Creek were recognized as highly significant natural features. Roaring Spring, Hodgson Mill Spring, Althea Spring, Crystal Spring, Rockbridge (Morris) Spring, and Double Spring were recognized as highly significant spring sites.

Since the initial natural features inventory effort, the Missouri Natural Heritage Database (NHD) has been created. The database lists many of the features which are included in the Missouri Natural Features Inventory. The database, which is updated frequently, is a dynamic representation of the occurrence of many natural features in Missouri. Currently the database contains 294 features for the North Fork Watershed. These include 49 examples of 18 types of natural communities: The North Fork River, Bryant

Creek, and Spring Creek are recognized as significant examples of Ozark creek and small river communities (MDC 1999c). Unique and outstanding dolomite bluffs, glades, and dry mesic chert forests are common throughout the watershed. Recorded occurrences of natural features currently (1999) in the NHD for the North Fork Watershed include

- Caves-6
- Creeks and Small Rivers (Ozark)-3 Dolomite Glade-10
- Dry Chert Forest-1
- Dry Limestone/Dolomite Cliff-1 Dry-Mesic Bottomland Forest-1 Dry-Mesic Chert Forest-3
- Dry-Mesic Chert Prairie-1 Dry-Mesic Sandstone Forest-1 Fen-8
- Fresh Water Marsh-1 Headwater Stream (Ozark)-1
- Mesic Limestone/Dolomite Forest-1 Moist Limestone/Dolomite Cliff-3 Moist Sandstone Cliff-3
- Pond Shrub Swamp-2 Prairie Fen-2
- Shrub Swamp-1

A detailed description of these terrestrial natural communities can be found in The Terrestrial Natural Communities of Missouri by Nelson (1987), while a detailed description of Missouri's aquatic communities can be found in Aquatic Community Classification System for Missouri by Pflieger (1989)

Undoubtedly more examples of natural features exist within the watershed. However due to many circumstances including the limited access to private land and the large land area, many features may be as yet unrecorded. Therefore, the previous listing of features should not be regarded as final. However, this listing does provide a good cross section of the types of communities which can be found within the watershed.

## Improvement Projects

There are currently (1998) 3 DSP-3 projects within the North Fork Watershed. These are intensive rotational grazing programs sponsored by the Natural Resource Conservation Service (NRCS) and involve alternative watering systems. All are in progress. There are 3 completed Landowner Cooperative Projects including a cedar tree revetment project completed in cooperation with the United States Forest Service and located at the North Fork Recreation Area. One other project is currently awaiting landowner approval (Pratt personal communication 1998). Table Hc01 lists all stream related projects in the watershed.

## Stream Habitat Assessment

In 1996 and 1998, stream and riparian habitat quality were evaluated at 13 sites within the North Fork Watershed. Of the 13 sites, 6 were located in the Bryant Creek Subwatershed, 6 in the North Fork Watershed above the Bryant Creek confluence, and 1 in the Norfork Lake and Tributaries Subwatershed. These sites generally corresponded to 1996 fish community sample sites. Habitat quality was assessed using the MDC Stream Habitat Annotation Device (SHAD II). Selected SHAD data was entered into a geographic information system (GIS) database based on a numerical system which enabled more efficient analysis of data. Sites were evaluated based on the following SHAD categories: "streambank erosion", "streambank erosion protection", "percent timbered stream corridor", and "narrowest width of timbered corridor". Numerical values associated with different levels of condition for each category were then assigned to left and right streambanks and corridors evaluated with 1 being extremely poor and 5 being excellent. These values were then averaged to give an overall grade for the site (Figure Hc02). The lowest grade within the North Fork Watershed was a 3 (fair). Three sites received this rating. Five sites were rated as 5 (excellent). The remaining five sites were rated as good.

There appears to be no significant distribution pattern of SHAD sites relative to grade. This illustrates the

complications of using SHAD data as a means for determining watershed and even subwatershed habitat condition. Depending on site selection methodology as well as the level of homogeny of habitat within a watershed, the SHAD can be a very site specific method of habitat evaluation. Thus, in most cases, the more broadly that SHAD data is applied to a watershed, the less accurate it becomes.

Perhaps one of the more difficult attributes of a watershed to attempt to quantify is stream habitat. This is due to the fact that there are several dynamic characteristics which make up stream habitat. To evaluate all of these characteristics individually and accurately for an entire watershed is a monumental task and beyond the scope of this document. Thus, the next best thing is to evaluate a characteristic that has the most impact on all aspects of stream habitat. This is, arguably, riparian corridor land cover/land use.

Riparian corridor land cover effects many aspects of stream habitat. These include, but are not limited to water temperature, turbidity, nutrient loading, sand/gravel deposition, instream cover, flow, channel width, and channel stability. These in turn have effects on still other characteristics of stream habitat such as food availability, dissolved oxygen, cover, spawning areas, etc.

Evaluation of riparian corridor land cover/land use within the North Fork Watershed was accomplished using Missouri Resource Assessment Partnership Phase 1 Land Cover Data(morapmd.wpd). A buffer zone 3 pixels (90 meters) wide was created which corresponded to a 1:100,000 hydrography coverage for the watershed. This was split into segments no longer than 0.25 miles long (Caldwell, personal communication). Percent land use for each segment was then calculated. Land cover/land use categories included forest, woodland, grassland, cropland, urban, and water. Percentages of these categories were then calculated for riparian corridors within each of the 30 fourteen digit hydrologic units, the 6 eleven digit hydrologic units within the watershed, as well as the whole watershed.

Results for the entire watershed indicate that riparian corridor land use consists of more forest/woodland (64.9%) than grassland/cropland (34.2%). Combined percentages for the remaining categories are less than 1% of the total riparian corridor land cover/land use in the watershed. Of the 6 eleven digit hydrologic units (HUs) within the watershed, the Upper North Fork HU has the highest combined percentage of forest/woodland corridor land cover/land use at 71.2%. It also has the lowest combined percentage of grassland/cropland corridor land use at 28.3%. This is due in large part to the fact that much of this section is part of the Mark Twain National Forest. Table Hc02 gives riparian corridor land cover/land use percentages for all fourteen digit hydrologic units within the watershed as well as percentages for the three major drainage sections of the watershed and the total watershed. Figure Hc03 presents a graphic representation of riparian corridor land cover/land use for all fourteen digit hydrologic units within the watershed.

An aerial stream survey of the North Fork River Watershed was made during March and April, 1996. The survey flight covered the entire length of the North Fork, Bryant Creek, and many other major tributaries. A catalog of the flight, highlighting stream and riparian destabilization areas and other significant landmarks has been completed. Highway and topographic maps have been labeled according to the video index time. The catalogs also include an index of slides taken during the flight. Information from this survey will be useful for a variety of projects such as future habitat assessment, assisting landowners with problems associated with stream bank erosion and deposition, reviewing gravel mining permits, selection of aquatic biota sampling sites, etc.

## Cold Water Habitat

Approximately 39 miles of stream within the North Fork Watershed are designated for cold-water sport fishery (Figure Hc04) (MDNR 1996a). Approximately 14 miles of the North Fork River are designated for cold-water sport fishery. Table Hc03 lists additional stream segments designated for cold-water sport fishery.

In an effort to further quantify cold water resources within the North Fork Watershed, instantaneous

stream temperatures were recorded at many stream crossings within the watershed during August of 1991, 1992, 1993, and 1994. Results from this preliminary study were then used to determine sites for placement of thermographs (long term temperature recorders). These were placed at 47 selected sites in the summer of 1995 and 1996 (Table Hc04). Thermographs were programmed to record temperatures every 2 hours. Period of record for the thermographs varied from 12-64 days. Average stream temperature at each site for period of record was determined and then compared to average air temperature (Mountain Grove) for period of record (Figure Hc04). Figure Hc05 displays results of comparisons of average stream temperature and average air temperature for sites exhibiting an average air temperature of 80 degrees Fahrenheit or higher. The higher average air temperature at these sites enables a more confident determination of spring influenced sites. Figure Hc06 shows the comparison of temperature graphs between air temperature, a spring influenced site, and a non-spring influenced site.

The limited period of record for some thermograph sites as well as a relatively mild summer in 1996 limits the use of some of this data. Results of comparisons between sites with different periods of record are questionable. Furthermore, sites with shorter periods of record or periods which occur later in the summer typically exhibit cooler average air temperatures and thus a smaller gradient between the average air and average stream temperature. Additional temperature study will be required in order to further determine spring influence within the watershed.


Figure He01.
North Fork Watershed
Dams
Hunter Cr.
Indian Cr.
Spring Cr.
Fox Cr.
Spring Cr.
Bryant Cr.
North Fork R.
Spring Cr.
Lick Cr.
Bennett's Bayou
Bennett's R.
1
2
3
4
4 0 4 8 Miles
Site
1 Dawt Mill Dam
2 Noblett Lake Dam
3 Althea Spring Branch Dam
4 Rock Bridge Dam
* Does not include earthen dams
N

Figure Hc02

# North Fork Watershed
## Stream Habitat Assessment

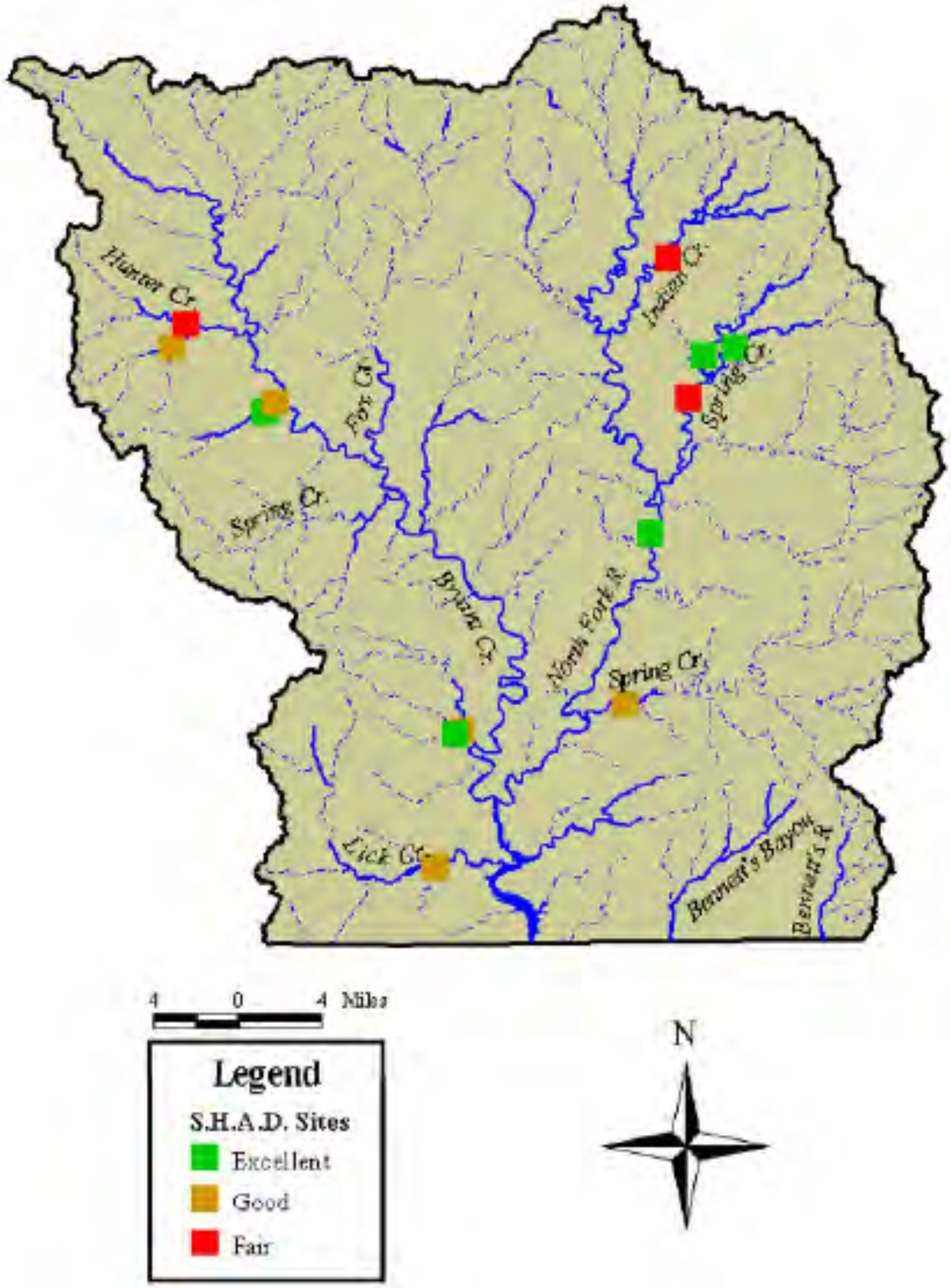


Figure Hc03.

# North Fork Watershed
## 14 Digit Hydrologic Unit Riparian Corridor Land Cover/Land Use

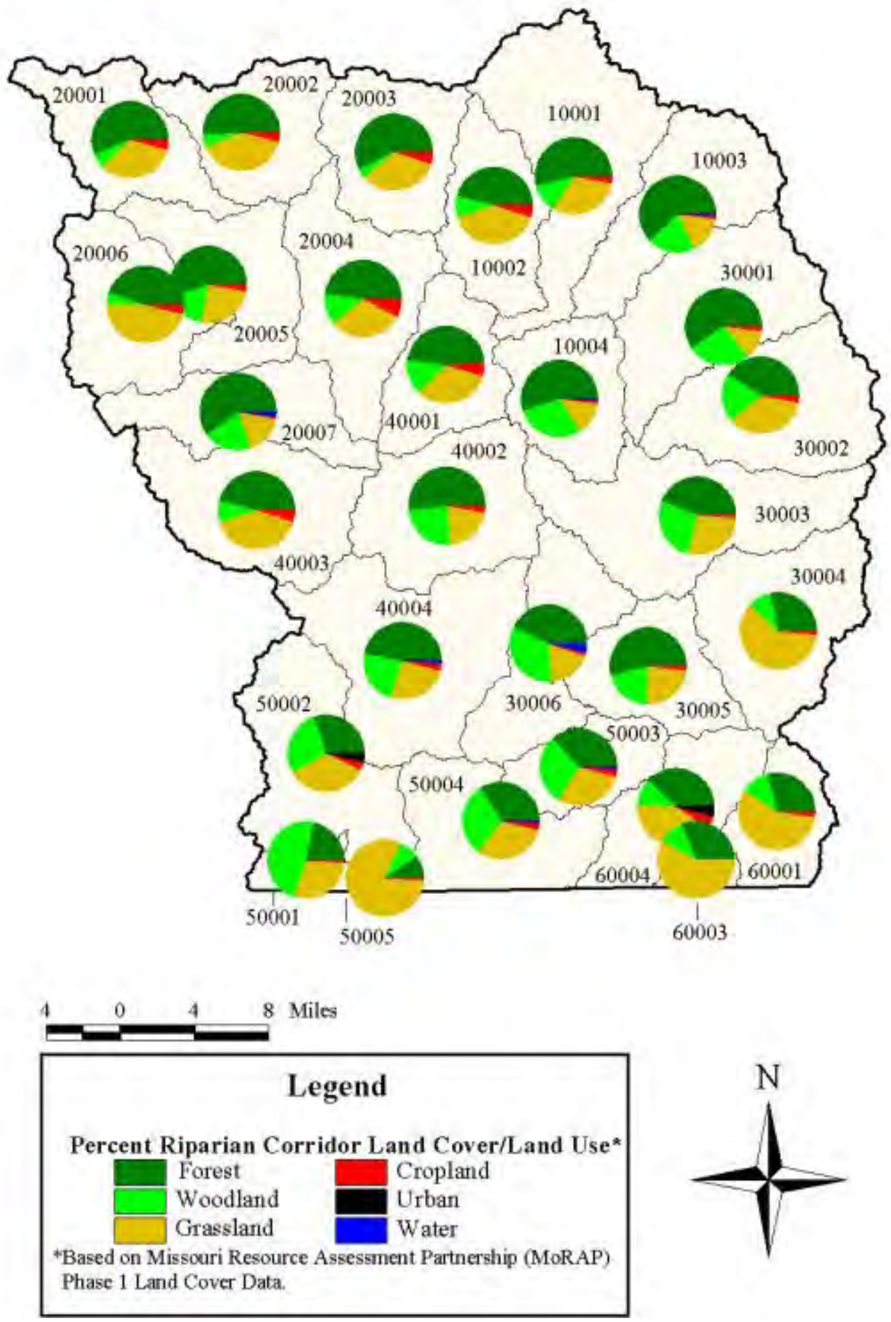


Figure Hc04.

# North Fork Watershed
## Thermograph Sites

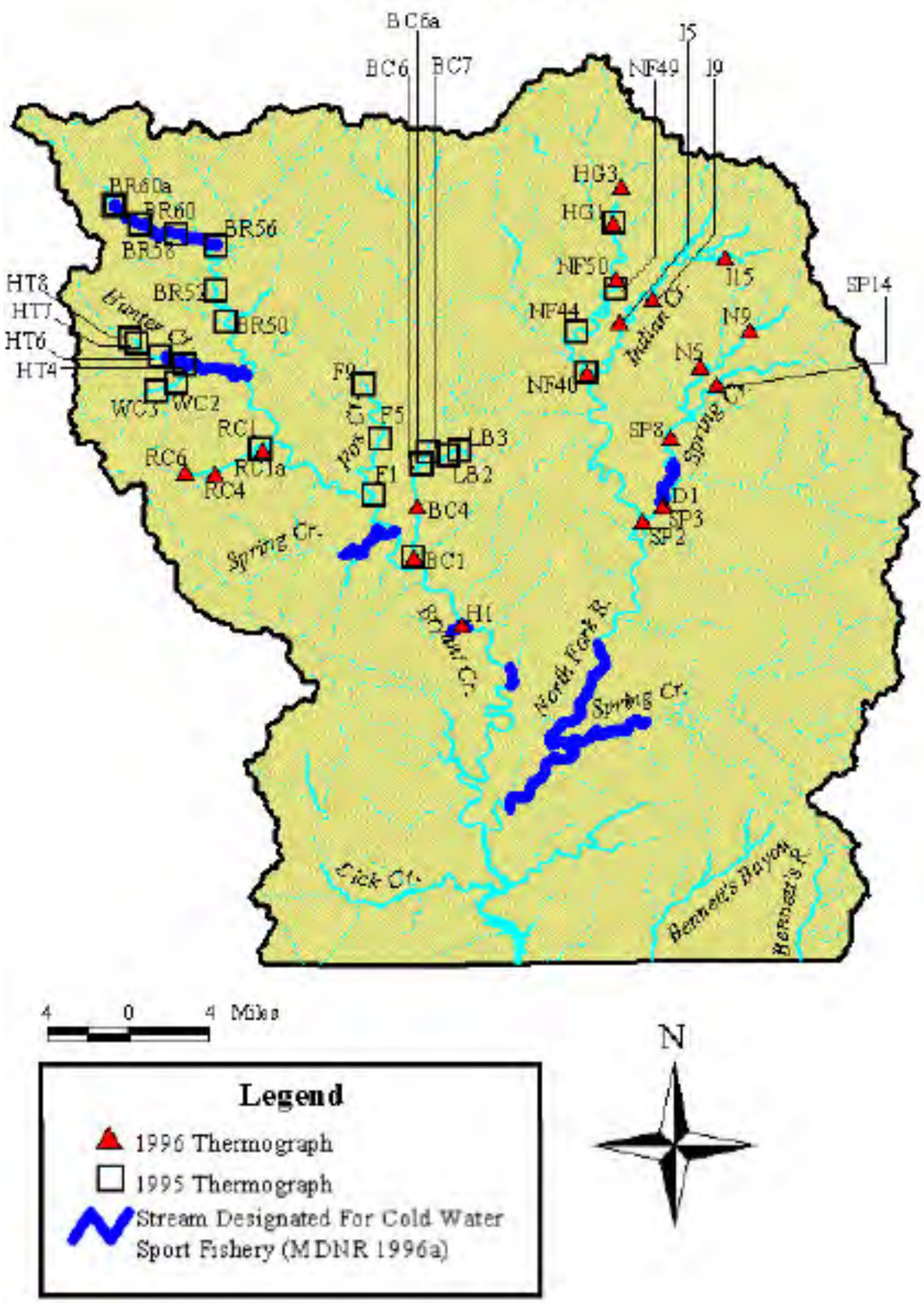


Figure Hc05. Comparison of 1995 average air temperature (Moutain Grove) and average stream temperature for selected sites within the North Fork Watershed.

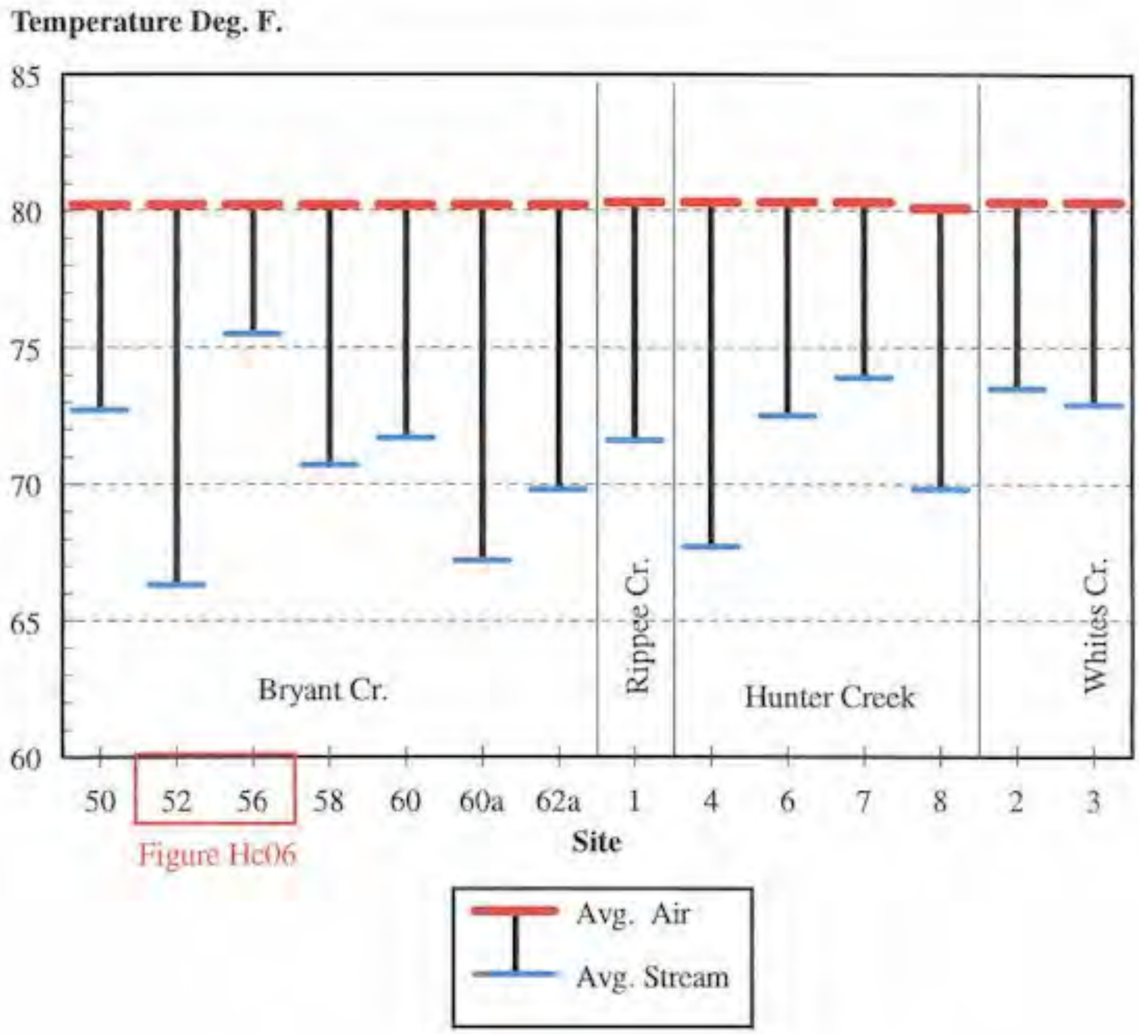


Figure Hc06. Comparison of 1995 air temperature (Moutain Grove) to site 52, exhibiting a substantial spring influence, and site 56 which does not exhibit a subtantial spring influence.

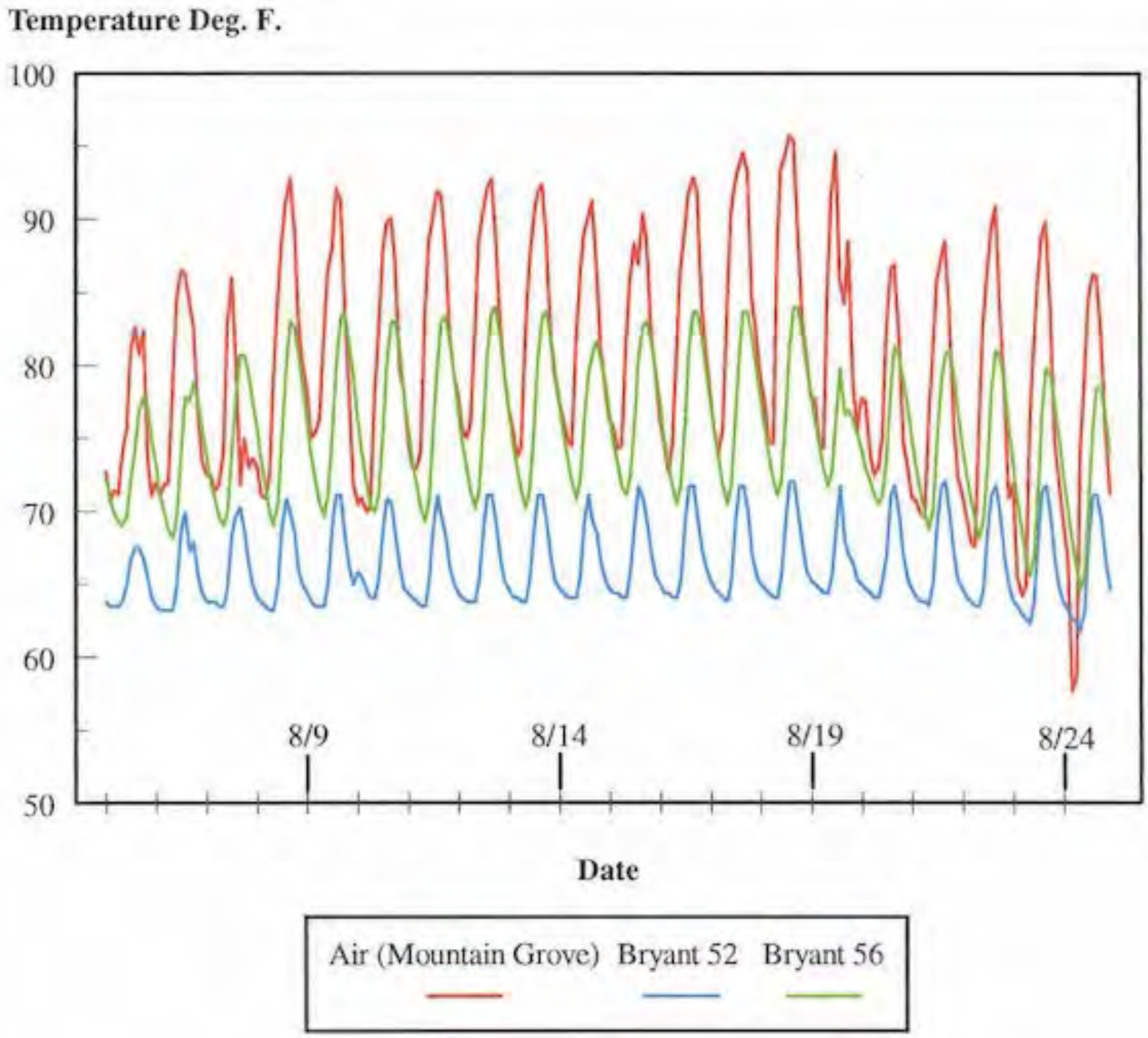


Table Hc01. Missouri Department of Conservation stream improvement projects within the North Fork River Watershed. (Pratt, personal communication)

| Affected Stream | Project Type | Completion Date |
|---|---|---|
| **Bryant Cr.** | Cedar Tree Revetment | May, 1997 |
| **Bryant Cr.** | Willow/Sycamore Pole Stabilization | winter/spring 1998 |
| **Spring Cr.** | In-Stream Habitat Improvement | winter/spring 1998 |
| **Bennett's Bayou** | Alternative Watering System | winter/spring 1998 |
| **S. Bridges Cr.** | Alternative Watering System | winter/spring 1998 |
| **Lick Cr.** | Willow/Sycamore Pole Stabilization | winter/spring 1998 |
| **North Fork R.** | Alternative Watering System | summer 1998 |
| **North Fork R.*** | Cedar Tree Revetment | summer 1994 |

*In cooperation with the United States Forest Service.

Table Hc02. Percent riparian corridor land use for 14 digit and 11digit (bold) hydrologic units within the North Fork Watershed. Data is based on MORAP Phase 1 Land Cover (1997) as analyzed by Caldwell (1998).

| Subwatershed | FOR | WDL | GRS | CRP | URB | WAT |
|---|---|---|---|---|---|---|
| **10001** | 54.2 | 11.7 | 30.5 | 3.2 | 0 | 0.4 |
| **10002** | 46.3 | 8.6 | 40.2 | 4.7 | 0 | 0.2 |
| **10003** | 62.5 | 19.7 | 16 | 1.4 | 0 | 0.4 |
| **10004** | 55.1 | 28.6 | 13.6 | 1.3 | 0 | 1.4 |
| **Upper North Fork** | 55.1 | 16.1 | 25.6 | 2.7 | 0 | 0.5 |
| **20001** | 56.2 | 5.7 | 34.3 | 3.6 | 0.1 | 0.1 |
| **20002** | 50.8 | 5.2 | 39.6 | 4 | 0.4 | <0.1 |
| **20003** | 56.7 | 4.2 | 33.9 | 5.3 | 0 | <0.1 |
| **20004** | 47.7 | 12.9 | 31.1 | 8.1 | 0 | 0.1 |
| **20005** | 54.6 | 17.3 | 24.6 | 3.3 | 0 | 0.2 |
| **20006** | 45.4 | 4.9 | 46 | 3.6 | 0 | <0.1 |
| **20007** | 60 | 20.7 | 17.1 | 1.3 | 0 | 0.9 |
| **Upper Bryant** | 53 | 10 | 32.4 | 4.3 | <0.1 | 0.2 |
| **30001** | 58.8 | 27.2 | 11.6 | 1.8 | 0 | 0.6 |
| **30002** | 40.8 | 20.4 | 35.5 | 3.3 | 0 | <0.1 |
| **30003** | 43.5 | 26.5 | 27.9 | 1.3 | 0 | 0.8 |
| **30004** | 28.7 | 8.5 | 60.1 | 2.4 | 0 | 0.3 |
| **30005** | 54.2 | 19.5 | 24.4 | 1.8 | 0 | 0.1 |
| **30006** | 42.9 | 33 | 18.6 | 0.8 | 0 | 4.7 |
| **Lower North Fork** | 44.6 | 22.3 | 30.2 | 1.9 | 0 | 0.9 |
| **40001** | 47.7 | 14.8 | 31.7 | 5.7 | 0 | 0.2 |
| **40002** | 51.6 | 24.2 | 20.8 | 2.5 | 0 | 0.9 |
| **40003** | 45.5 | 9.3 | 40.1 | 4.7 | 0 | 0.3 |
| **40004** | 46.7 | 22.7 | 26.2 | 2.9 | 0 | 1.6 |
| **Lower Bryant** | 47.6 | 18.3 | 29.6 | 3.7 | 0 | 0.9 |
| **50001** | 21.7 | 48.2 | 28.7 | 1.5 | 0 | 0 |
| **50002** | 30.3 | 28 | 35.1 | 2.7 | 3.8 | <0.1 |

| Subwatershed | FOR | WDL | GRS | CRP | URB | WAT |
|---|---|---|---|---|---|---|
| **50003** | 37.4 | 29.1 | 29.8 | 3.1 | 0 | 0.6 |
| **50004** | 34.1 | 30.5 | 30.8 | 3.4 | 0 | 1.2 |
| **50005** | 11.4 | 8.1 | 79.4 | 1.1 | 0 | 0 |
| **West Norfork Lake** | 31.5 | 30.7 | 32.7 | 2.8 | 1.7 | 0.4 |
| **60001** | 29.1 | 12.2 | 57.1 | 1.6 | 0 | 0 |
| **60003** | 31 | 11 | 57.9 | 0 | 0 | 0 |
| **60004** | 37.7 | 11.1 | 42 | 4.5 | 4.7 | <0.1 |
| **East Norfork Lake** | 32.7 | 11 | 46.9 | 2.9 | 2.5 | <0.1 |
| **North Fork Watershed** | 47.1 | 17.8 | 31.1 | 3.1 | 0.3 | 0.6 |

**FOR** =Forest, **WDL**=Woodland, **GRS**=Grassland, **CRP**=Cropland, **URB**=Urban, **WAT**=Water

Table Hc03. Streams designated for cold-water sport fishery within the North Fork Watershed by MDNR (1996a). Location given in section, township and range format.

| Stream Name | Miles | From | To | County |
|---|---|---|---|---|
| **Bryant Creek** | 1 | 3,23N,12W | 34,24N,12W | Ozark |
| **Bryant Creek** | 6 | 19,27N,14W | 8,27N,15W | Douglas |
| **Hunter Creek** | 5 | 22,26N,15W | 20,26N,15W | Douglas |
| **Hurricane Creek** | 1.5 | Mouth | 30,24N,12W | Ozark |
| **North Fork River** | 13.5 | 3,22N,12W | 28,24N,11W | Ozark |
| **Spring Creek (Bryant)** | 3 | Mouth | 5,24N,13W | Douglas-Ozark |
| **Spring Creek (North)** | 2.5 | Mouth | 26,25N,11W | Douglas |
| **Spring Creek (South)** | 5 | Mouth | 14,23N,11W | Ozark |
| **Turkey Creek** | 1 | Mouth | 17,23N,15W | Ozark |

Table Hc04. Average stream temperature (deg. Fahrenheit) and air temperature (Mountain Grove) for thermograph Sites within the North Fork Watershed. Average stream temperature is based on observations every 2 hours. Average air temperature is based on observations every hour.

| Site | Stream | In Date | Out Date | n | Avg. Stream Temp. | Avg. Air Temp. |
|---|---|---|---|---|---|---|
| **BC1** | Brush Cr. | 19950830 | 19950912 | 168 | 70 | 70.6 |
| **BC6** | Brush Cr. | 19950830 | 19950912 | 168 | 65.8 | 70.6 |
| **BC6a** | Brush Cr. | 19950830 | 19950912 | 168 | 63.9 | 70.6 |
| **BC7** | Brush Cr. | 19950830 | 19950912 | 168 | 69.1 | 70.6 |
| **BC1** | Brush Cr. | 19960718 | 19960910 | 660 | 72.8 | 73.6 |
| **BC4** | Brush Cr. | 19960717 | 19960910 | 660 | 71.9 | 73.6 |
| **BR50** | Bryant Cr. | 19950805 | 19950824 | 240 | 72.7 | 80.2 |
| **BR52** | Bryant Cr. | 19950805 | 19950824 | 240 | 66.3 | 80.2 |
| **BR56** | Bryant Cr. | 19950805 | 19950824 | 240 | 75.5 | 80.2 |
| **BR58** | Bryant Cr. | 19950805 | 19950824 | 240 | 70.7 | 80.2 |
| **BR60** | Bryant Cr. | 19950805 | 19950824 | 240 | 71.7 | 80.2 |
| **BR60a** | Bryant Cr. | 19950805 | 19950824 | 240 | 67.2 | 80.2 |
| **BR62a** | Bryant Cr. | 19950805 | 19950824 | 240 | 69.8 | 80.2 |
| **D1** | Dry Cr. | 19960724 | 19960909 | 576 | 67.1 | 72.9 |
| **F1** | Fox Cr. | 19950903 | 19950914 | 144 | 70.1 | 68.3 |
| **F5** | Fox Cr. | 19950903 | 19950914 | 144 | 68.8 | 68.3 |
| **F9** | Fox Cr. | 19950903 | 19950914 | 144 | 64.6 | 68.3 |
| **H1** | Hurricane Cr. | 19960718 | 19960919 | 768 | 64.9 | 71.9 |
| **HG1** | Hungry Cr. | 19950903 | 19950914 | 144 | 63.8 | 68.3 |
| **HG1** | Hungry Cr. | 19960701 | 19960910 | 492 | 68.1 | 73.2 |
| **HG3** | Hungry Cr. | 19960701 | 19960910 | 492 | 68 | 73.2 |
| **HT6** | Hunter Cr. | 19950806 | 19950827 | 264 | 72.5 | 80.3 |
| **HT7** | Hunter Cr. | 19950806 | 19950827 | 264 | 73.9 | 80.3 |
| **HT4** | Hunter Cr. | 19950806 | 19950827 | 264 | 67.7 | 80.3 |
| **I15** | Indian Cr. | 19960726 | 19960918 | 660 | 70.8 | 71.1 |

| Site | Stream | In Date | Out Date | n | Avg. Stream Temp. | Avg. Air Temp. |
|---|---|---|---|---|---|---|
| **I5** | Indian Cr. | 19960726 | 19960919 | 672 | 64.5 | 70.9 |
| **I9** | Indian Cr. | 19960726 | 19960918 | 660 | 72.3 | 71.1 |
| **LB2** | L. Brush Cr. | 19950830 | 19950911 | 156 | 65.9 | 70.5 |
| **LB3** | L. Brush Cr. | 19950830 | 19950911 | 156 | 67.3 | 70.5 |
| **N5** | Noblett Cr. | 19960724 | 19960909 | 576 | 71.4 | 72.9 |
| **N9** | Noblett Cr. | 19960724 | 19960918 | 684 | 69.3 | 71.2 |
| **NF40** | North Fork R. | 19950903 | 19950914 | 144 | 67.6 | 68.3 |
| **NF44** | North Fork R. | 19950903 | 19950914 | 144 | 65.8 | 68.3 |
| **NF49** | North Fork R. | 19950903 | 19950914 | 144 | 69.6 | 68.3 |
| **NF40** | North Fork R. | 19960701 | 19960910 | 492 | 71.5 | 73.2 |
| **NF50** | North Fork R. | 19960701 | 19960910 | 492 | 73.3 | 73.2 |
| **RC1a** | Rippee Cr. | 19950806 | 19950827 | 264 | 71.6 | 80.3 |
| **RC1** | Rippee Cr. | 19960717 | 19960910 | 672 | 69.5 | 73.8 |
| **RC4** | Rippee Cr. | 19960717 | 19960910 | 672 | 67.8 | 73.8 |
| **RC6** | Rippee Cr. | 19960717 | 19960910 | 672 | 70.3 | 73.8 |
| **SP14** | Spring Cr. | 19960724 | 19960918 | 684 | 68.4 | 71.2 |
| **SP2** | Spring Cr. | 19960724 | 19960909 | 588 | 67 | 72.9 |
| **BS1** | Big Spring Br. | 19960724 | 19960909 | 588 | 74.6 | 72.9 |
| **SP8** | Spring Cr. | 19960724 | 19960909 | 588 | 67 | 72.9 |
| **TC** | Turkey Cr. | 19950805 | 19950827 | 264 | 69.8 | 80.1 |
| **WC2** | Whites Cr. | 19950806 | 19950827 | 264 | 73.5 | 80.3 |
| **WC3** | Whites Cr. | 19950806 | 19950827 | 264 | 72.9 | 80.3 |

**n**=number of stream temperature observations for period of record.

# Biotic Communities

## Stream Fish Distribution and Abundance

Historical records of fish collections within the North Fork Watershed date back to 1 July, 1931. The latest fish community surveys were performed in 1997 (Figure Bc01) (MDC 1998a). From 1931 to 1997, 76 fish species (not including hybrids) in 15 families have been collected (including observations) within the watershed (Table Bc01) (MDC Ozark Regional Fish Collection Files; MDC Sport Fish Collection Files; Pflieger 1997; MDC 1998a; MDC 1999c). Table Bc02 shows fish species distribution by 11 digit hydrologic unit.

Prior to 1980, a total of 65 fish species (not including hybrids) in 12 families were collected (including observations) within the watershed (MDC Ozark Regional Fish Collection Files; MDC Sport Fish Collection Files; Pflieger 1997; MDC 1998a; MDC 1999c).

From 1980 to 1997, a total of 71 species in 15 families have been collected (MDC Ozark Regional Fish Collection Files; MDC Sport Fish Collection Files; Pflieger 1997; MDC 1998a; MDC 1999c). Three species of fish which were observed prior to 1980 were not observed from 1980 to 1997. These include the Gilt Darter *(Percina evides),* steelcolor shiner *(Cyprinella whipplei),* and the least brook lamprey *(Lamptera aepyptera).* The gilt darter and the steelcolor shiner were only collected in 1942 from a single site (MDC 1998a). This site became part of Norfork Lake whose dam was completed in 1944 (MDNR 1994a). Pflieger (1997) states that the gilt darter "has apparently disappeared from the White River Basin following the construction of the North Fork, Table Rock, and Bull Shoals Reservoirs." Pflieger (1997) gives a similar description of the disappearance of the steelcolor shiner within the basin.

Of some concern is the absence of the least brook lamprey in collections after 1979.

The least brook lamprey has only been collected in 5 samples within the watershed; all of which occurred between 1969 and 1979 (MDC 1998a). Larval lamprey have been collected in samples after 1979. These perhaps may be representatives of the least brook lamprey. Additional sampling will be necessary in order to adequately determine the status of this species within the North Fork Watershed.

Four species of fish have been collected in fish community samples since 1980 which were not previously recorded in MDC fish community collections prior to 1980 within the watershed (MDC Ozark Regional Fish Collection Files; MDC Sport Fish Collection Files; Pflieger 1997; MDC 1998a; MDC 1999c). These include the longnose gar, redspotted sunfish, warmouth, and western mosquitofish. All species, with the exception of the longnose gar, have been collected at single sites. The redspotted sunfish and warmouth were both collected at the same site on Bryant Creek. The western mosquitofish was collected at a single site on Bennett's River. The longnose gar was collected at two relatively widely separated sites; one on Lick Creek and the other on the North Fork River. It is difficult to determine the exact cause of the sudden appearance of these species within the watershed. Possible explanations could include a change in sampling techniques, sampling effort, or undocumented introductions.

The longnose gar was collected at one site on Lick Creek which had not been previously sampled. Sampling methodology at the other site at which the longnose gar was collected was slightly different than for earlier samples (MDC 1998a).

The western mosquitofish was collected at a site which had not previously been sampled. In addition, this species has been collected from nearby streams within the neighboring Spring River Tributaries Watershed; Thus, its new found presence in the North Fork Watershed should be of no surprise especially in light of how this species has spread so quickly throughout the state. A survey in the 1940s indicated that its distribution in Missouri included the "Lowland Faunal Region and northward along the Mississippi River to Ramsey Creek in Pike County"(Pflieger 1997). Today the mosquito fish can be found in all of the faunal regions of the state.

The appearance of the redspotted sunfish and the warmouth is more difficult to explain than the previously mentioned species. Sample methods between the sample in which these species were found and an earlier sample appear to be similar. Both the warmouth and the redspotted sunfish have been collected in the neighboring Bull Shoals Lake Watershed, Part of the White River Tributaries Watershed (Pflieger 1997). Neither are widespread in the southwestern portion of the Ozarks. The occurrence of these species within the North Fork Watershed are probably the result of undocumented introductions.

Percent of occurrence for individual species was determined by dividing the number of sample sites at which an individual species was collected by total number of sample sites within the North Fork Watershed for the entire period of record. Six species occurred at 75% or more of the sample sites: banded sculpin (Cottus carolinae), central stoneroller *(Campostoma pullum),* duskystripe shiner *(Luxilis pilsbryi),* hornyhead chub *(Nocomis biguttatus),* Ozark sculpin *(Cottus hypselurus),* and rainbow darter *(Etheostoma caeruleum).*

In addition to the previously mentioned species, 5 additional species of fish have been observed in sport fish samples within the North Fork Watershed. These include black crappie, white crappie, striped bass, white bass, and river redhorse. The occurrence of most of these species is probably due to the effect of the recreational fishery management and habitat of Norfork Lake on fish community species composition.

The fish fauna of the North Fork Watershed is dominated by Ozark species (Table Bc01). According to the faunal region classification of species as developed by Pflieger (1989), they could be described as 57% Ozark, 8% Ozark-Prairie, 8% Ozark-lowland, 3% Ozark-Big River, 1% Prairie, 3% Big River,

Lowland 3% and 17% widely distributed. Sport Fish

The tributaries and lakes of the North Fork Watershed offer a wide variety of angling opportunities. A total of 16 species of sport fish (as defined as game fish in MDC 1999c) are known to occur within the watershed (Pflieger 1997; MDC 1998a; MDC sport fish sample files; Pratt, personal communication). These include grass pickerel, chain pickerel, rainbow trout, brown trout, Ozark bass, smallmouth bass, largemouth bass, channel catfish, warmouth, walleye, spotted bass, flathead catfish, black crappie, white crappie, striped bass, and white bass. Walleye, spotted bass, flathead catfish, black crappie, white crappie, striped bass, and white bass have a distribution associated primarily with Norfork Lake as well as the lower North Fork River and lower Bryant Creek. White bass, striped bass, and walleye move up into the lower tributaries, primarily the North Fork River and Bryant Creek, during the spring as part of their spawning activity.

The North Fork River from Rainbow Spring to Dawt Mill has year round temperatures less than 70oF and is managed as a cold-water fishery. This section of the North Fork River is home to an important and nationally recognized trout fishery. Both rainbow and brown trout exist in this area. The North Fork of the White River in Ozark County is classified as a Wild Trout Management Area from the upper outlet of Rainbow Spring to Blair Bridge. The unimpounded portion of the North Fork River and its tributaries from Blair Bridge to Norfork Lake are managed as a Special Trout Management Area (MDC, 1999d).

Special regulations apply in both areas (see current Missouri Wildlife Code Booklet).

In 1991 and 1992 an angler survey was carried out within the section of the North Fork River designated as a cold-water fishery (approximately 13.5 miles). Results indicated that angler visitation equaled an annual average 452 trips/mile per year and helped to generate more than half a million dollars for the local economy (Zurbrick 1997).

Several species of non-game fish also provide many alternative fishing opportunities. These species include northern hogsucker, black redhorse, golden redhorse, and shorthead redhorse. (MDC 1998a; MDC sport fish sample files)

## Fish Stocking

Due to the existence of a significant cold water fishery within the North Fork Watershed, fish stocking efforts have been primarily focused on trout. The first recorded introduction of rainbow trout within the watershed was in 1925 (Zurbrick 1997). Stocking of rainbow trout was discontinued by Missouri Department of Conservation (MDC) in 1966 and the population became self-sustaining through natural reproduction. In 1967, MDC began stocking brown trout in the North Fork River. Since then 378,229 brown trout have been stocked in the North Fork (MDC 1974-1979,1986 and MDC 1985-1996).

Rainbow trout are stocked by two private entities within the watershed. Spring Creek, a tributary of the North Fork River is stocked on a semi-weekly basis from Memorial Day to Labor Day (Pratt personal communication). The other private trout area is located on Spring Creek (tributary of Bryant Creek).

Less information is known regarding the stocking of warm water species within the North Fork watershed. Missouri Department of Conservation (MDC) annual stocking reports for the Ozark Region indicate that Noblett Lake, the only major impoundment, besides Norfork Reservoir, within the watershed, receives annual supplemental stockings of channel catfish. Norfork reservoir receives the bulk of warmwater fish stockings in the watershed. The Missouri Department of Conservation routinely stocks walleye in the reservoir in Missouri (Legler, personal communication). In addition, the Arkansas Game and Fish Commission has stocked redear, black crappie, white crappie, channel catfish, blue catfish, flathead catfish, striped bass, and hybrids (white bass X striped bass) within the reservoir in Arkansas (Legler, personal communication). Many farm ponds have also been stocked with largemouth bass, bluegill, and channel catfish by both MDC and privately obtained fish. It can be assumed that many pond owners have also probably stocked grass carp. The potential of these fish being washed into streams exists in all major precipitation events. A lack of historical records, plus the occurrence of undocumented introductions makes it difficult to determine, with any reliability, all species which may have been introduced into the watershed. Effects of introductions vary. While the introduction of species already present in the watershed may have minimal to no effect, the introduction of non-native species can often times have disastrous consequences.

## Mussels

A total of 21 species of mussels are known to occur within the North Fork Watershed (Table Bc03)( Oesch 1995, Buchanan 1996, MDC 1998b, Turgeon et al. 1998). Of these, 3 species are former Federal category-2 candidates. These are the elktoe *(Alsmidonta marginata)*, Ouachita kidneyshell *(Ptychobranchus occidentalis),* and purple lilliput *(Toxolasma lividus).* Figure Bc02 displays Mussel sampling sites within the watershed.

## Snails

Fifteen species of snails have been identified within the North Fork Watershed (Table Bc04) (Wu etal. 1997). These include two species of conservation concern: the Arkansas mudalia *(Leptoxis arkansensis)* and the Ozark pyrg *(Pyrgulopsis ozarkensis)* (MDC 1999e).

## Crayfish

Five species of crayfish are known to occur within the North Fork Watershed. These include the longpincered crayfish *(Orconectes longidigitus),* northern crayfish *(Orconectes virilis),* Ozark crayfish *(Orconectes ozarkae),* ringed crayfish (*Orconectes n. chaenodactylus),* and spothanded crayfish *(Orconectes punctimanus)* ( Pflieger 1996 and MDC 1998c). Three species have distributions in or closely associated with the Ozark Region (Pflieger 1996). The longpincered crayfish is found only in the White River Basin in Missouri and Arkansas. The Ozark crayfish is found only in the White and Black River Basins in Missouri and Arkansas. It is uncommon in the North Fork Watershed. The spothanded

crayfish is found in the eastern half of the Ozarks in Missouri and adjacent counties in Arkansas. This species is also found in Callaway, Montgomery, and Warren Counties north of the Missouri River.

## Benthic Invertebrates

A limited amount of information is currently available for the North Fork Watershed in regard to benthic invertebrates. Duchrow (1977) carried out benthic invertebrate sampling at eight locations on Bryant Creek, Hunter Creek, Watered Hollow, and Crystal Spring Branch within the North Fork Watershed from 1974-1976 (Table Bc05 and Figure Wq04) (MDC 1998d). A total of 24,418 organisms of 106 taxa were collected. Densities ranged from 653 organisms/ft2 - 2538 organisms/ft2. All of these invertebrate sample sites were located in the Bryant Creek Subwatershed. Little is known in regard to the aquatic invertebrate community of the remainder of the North Fork Watershed. In order to gain further understanding of species composition and distribution throughout the watershed, additional sampling will be necessary.

## Species of Conservation Concern

Within the North Fork Watershed, 65 species of conservation concern have been identified (Table Bc06) (MDC 1999b and MDC 1999e). These include 41 species of plants; 2 species of insects; 6 species of mollusk; 3 species of fish; 1 species of amphibian, 2 species of reptiles, 5 species of birds; and 5 species of mammals. Three species have federal endangered and state endangered species status. These include the gray bat, Indiana bat, and running buffalo clover. An additional 4 species have state endangered species status. These are the mountain lion, black-tailed jackrabbit, Bachman's sparrow, and Swainson's warbler. The bald eagle is listed as a federal threatened species and a state endangered species. It is currently proposed for federal delisting (USFWS 2001).
The following is a brief description of aquatic oriented species of conservation concern within the North Fork Watershed:

## Fish

- **Lake chubsucker -** Only one record of this species exists within the Natural Heritage Database for the North Fork Watershed (MDC 1999b). The year of the observation is 1942. Historical data from the Missouri Department of Conservation Fish Collection Database indicate no collections of this species within the watershed. Pflieger (1997) describes this species as being primarily restricted to the Lowland Faunal Region with rare occurrences in the eastern Ozarks. For this reason, as well as a lack of historical observations within the watershed, the absence of this species from the North Fork Watershed should not be a concern.
- **Ozark Shiner -** The first record of the occurrence of the Ozark shiner within the North Fork Watershed is from 1931 (MDC 1998a). Since this time the Ozark shiner has been collected at 8 sites in 11 collections with the latest collections in 1996. The Ozark shiner has only been found within the Ozark uplands in Missouri and Arkansas (Pflieger 1997). Periodic monitoring will be needed in order to track the status of this species within the watershed over time.
- **Checkered Madtom -** The checkered madtom has been collected at 4 sites in 8 collections within the North Fork Watershed from 1940 to 1994 (MDC 1998a). Two of these sample sites no longer exist, having been inundated by the waters of Norfork Lake in the 1940s. Pflieger (1997) states that although the checkered madtom may have been eliminated from a portion of its former range by reservoir construction in the White River Basin it is still found in Norfork Lake. Pflieger also states, however, that this species appears to continue to decline. The checkered madtom is known only to occur in streams of the southern Ozarks from the upper White River to the Current River (Pflieger 1997). Periodic monitoring will be needed in order to track the status of this species within the watershed over time.

## Amphibians

- **Ozark Hellbender -** The Ozark Hellbender is restricted to the North Fork Watershed and to rivers and streams of the Black River System (Johnson 1992).

## Reptiles

- **Alligator Snapping Turtle** - The Natural Heritage Database currently lists one record (1992) for the alligator snapping turtle within the North Fork Watershed (1999b). Johnson (1992) states that the alligator snapping turtle is "presumed to occur in the large rivers, sloughs, and oxbow lakes of southern, southeastern and eastern Missouri."

## Invertebrates

### Elktoe (mussel)

The elktoe has only been found at a single site within the North Fork Watershed (Oesch 1984, Buchanan 1996, and MDC 1998b). Oesch 1984 states that the elktoe is usually not abundant where it is found. Host fishes for the elktoe include white sucker, northern hogsucker, shorthead redhorse, rock bass, and warmouth (Oesch 1984).

### Arkansas Broken-ray (mussel)

The Arkansas broken-ray was found at 16 sites within the North Fork Watershed in 1982 (MDC 1998b).

### Arkansas Mudalia (snail)

The Arkansas mudalia has been found at three sites within the North Fork Watershed. In Missouri, this species is only known to occur within the North Fork Watershed.

### Ouachita Kidneyshell (mussel)

The Ouachita kidneyshell has been collected from 11 sites within the North Fork Watershed. The last collection occurred in 1985 (MDC 1998b). While the Ouachita kidneyshell is fairly widespread south of the Missouri River, it is seldom abundant locally (Oesch 1984).

### Ozark Pyrg (snail)

The Ozark Pyrg has been collected from a single site within the North Fork Watershed. As is the case with the Arkansas mudalia, in Missouri, the Ozark pyrg is found only within the North Fork Watershed.

### Purple Lilliput (mussel)

The Purple Lilliput was collected from 2 sites within the North Fork Watershed in 1982 (MDC 1998b). Some of the pictures are courtesy of Native Fish Conservancy.

Figure Bc01.

# North Fork Watershed

## Fish Community Sample Sites

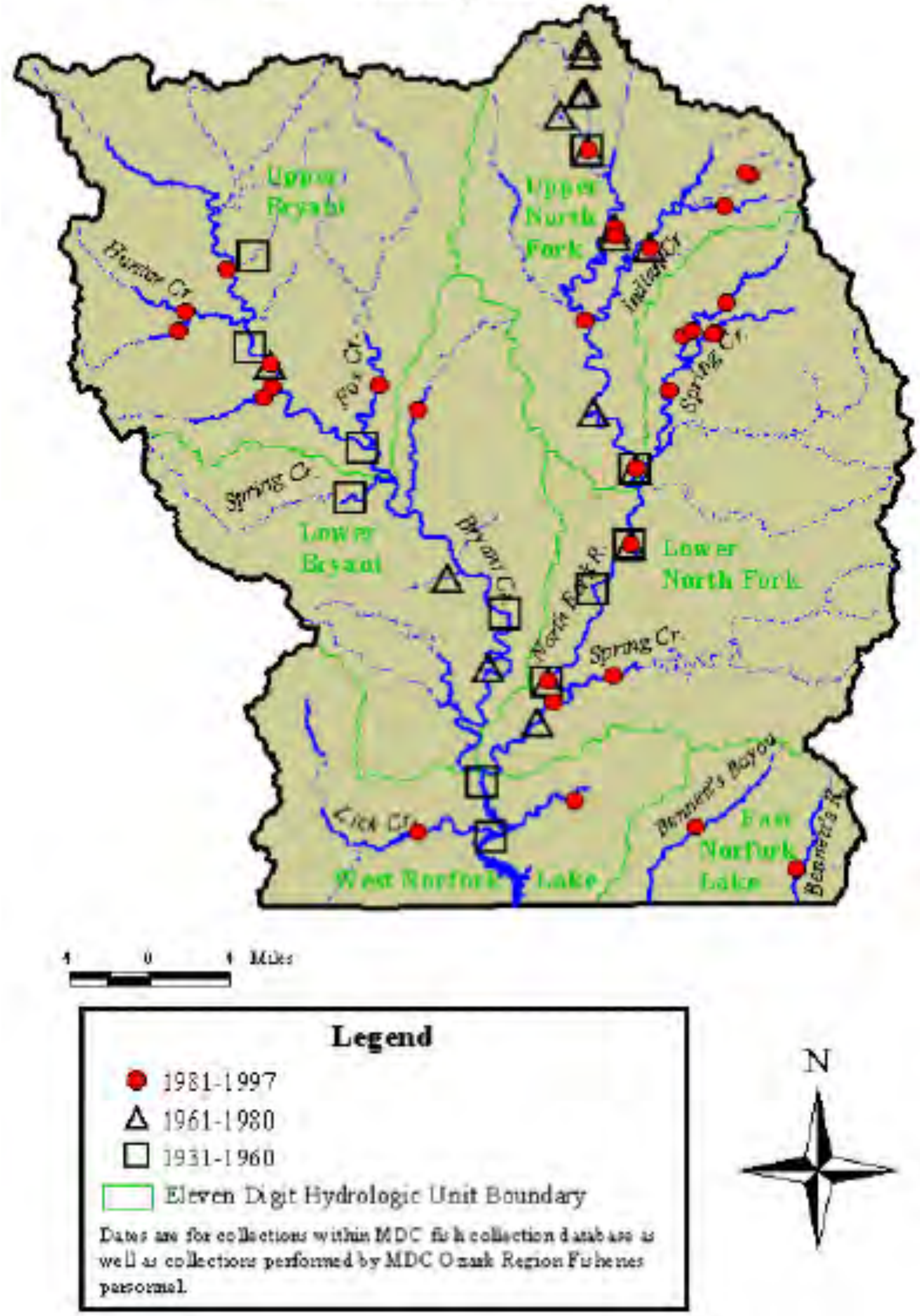


Figure 8c02.

# North Fork Watershed
## Mussel Community Sample Sites

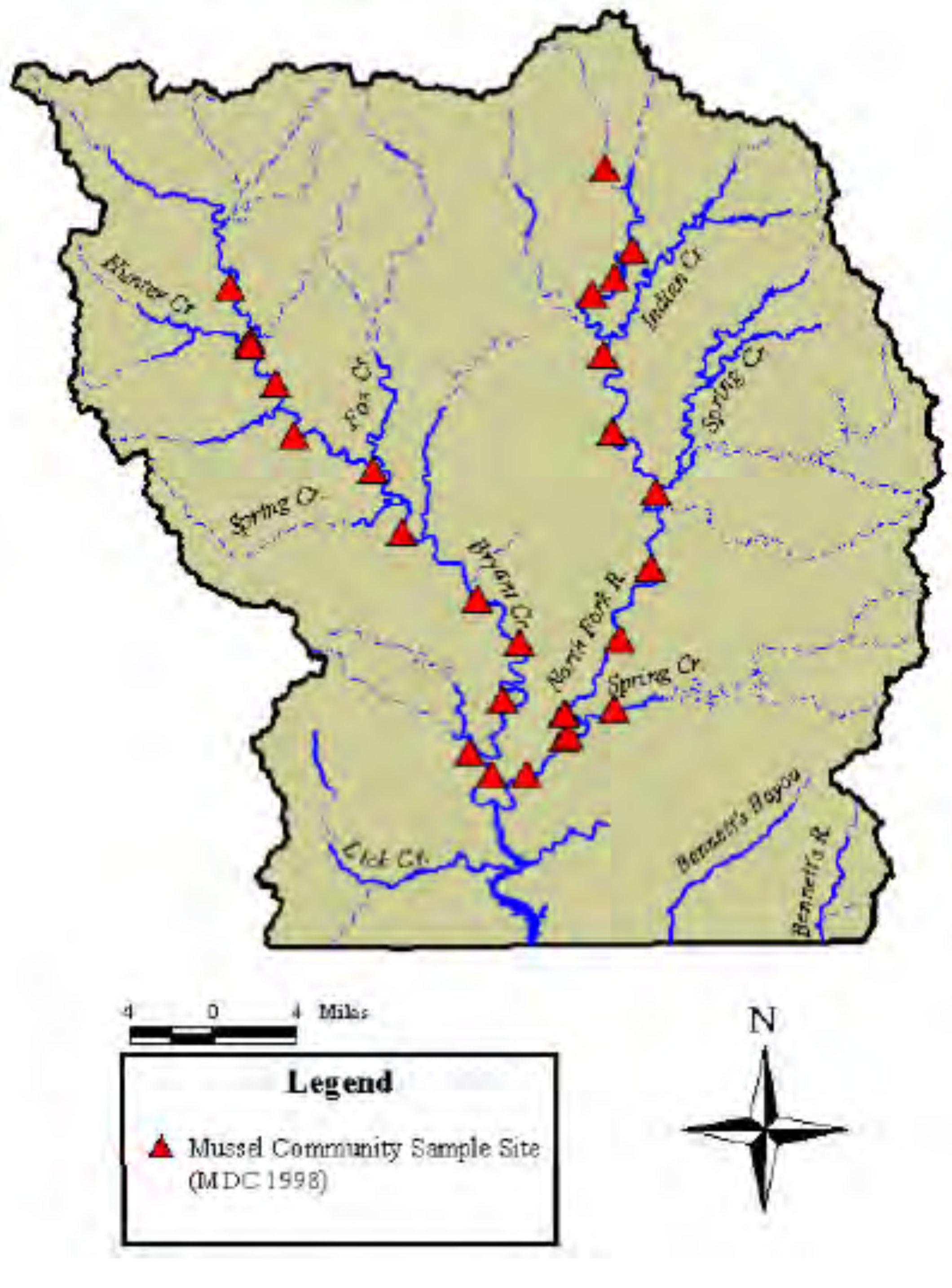


Table Bc01. Fish species with a distribution range of the North Fork Watershed. Key to Status: (1 of 4) 1 = collected 1931 to 1960; 2 = collected 1961 to 1980; 3 = collected 1981 to 1997 (MDC Ozark Regional Fish Collection Files; MDC Sport Fish Collection Files; Pflieger 1989; Pflieger 1997; MDC 1998a; MDC 1999c).

| Common Name | Geo Affinity[1] | Percent Occurrence[2] | Scientific Name | Sam.[3] Date |
|---|---|---|---|---|
| **Banded darter** | O | 29 | *Etheostoma zonale* | 1-2-3 |
| **Banded sculpin #** | O | 78 | *Cottus carolinae* | 1-2-3 |
| **Bigeye chub** | O | 31 | *Notropis amblops* | |
| **Bigeye shiner #** | O | 14 | *Notropis boops* | 1-3 |
| **Black crappie** | WIDE | - | *Pomoxis nigromaculatus* | 3* |
| **Black bullhead** | P | 4 | *Ameirus melas* | 1-3 |
| **Black redhorse #** | O | 25 | *Moxostoma duquesnei* | 1-2-3 |
| **Black spotted topminnow #** | L,O | 59 | *Fundulus olivaceus* | 1-2-3 |
| **Bluegill** | WIDE | 29 | *Lepomis macrochirus* | 1-2-3 |
| **Bluntnose minnow** | WIDE | 20 | *Pimepales notatus* | 1-2-3 |
| **Brook silverside #** | O | 4 | *Labidesthes sicculus* | 1-3* |
| **Brown trout** | O | 8 | *Salmo trutta* | 2-3 |
| **Central stoneroller** | O,P | 84 | *Campostoma pullum* | 1-2-3 |
| **Chain pickerel** | O | 4 | *Esox niger* | 1-3 |
| **Channel catfish** | WIDE | 10 | *Ictalurus punctatus* | 1-2-3* |
| **Checkered madtom** | O,L | 8 | *Noturus flavater* | 1-2-3 |
| **Chestnut Lamprey** | O,R | 4 | *Ichthyomyzon castaneus* | 1-3 |
| **Common carp** | WIDE | 4 | *Cyprinus carpio* | 2-3* |
| **Creek chub** | O,P | 27 | *Semotilus atromaculatus* | 1-2-3 |
| **Creek chubsucker** | O | 18 | *Erimyzon oblongus* | 1-2-3 |
| **Duskystripe Shiner** | O | 84 | *Luxilus pilsbryi* | 1-2-3 |
| **Flathead catfish** | WIDE | 2 | *Pylodictis olivaris* | 1-3* |
| **Gilt darter** | O | 2 | *Percina evides* | 1 |
| **Gizzard shad** | WIDE | 2 | *Dorosoma cepedianum* | 2-3* |
| **Golden redhorse #** | O,P | 18 | *Moxostoma erythrurum* | 1-2-3 |

| Common Name | Geo Affinity[1] | Percent Occurrence[2] | Scientific Name | Sam.[3] Date |
|---|---|---|---|---|
| **Golden shiner** | WIDE | - | *Notemigonus crysoleucas* | 2 |
| **Grass Pickerel** | L,O | 27 | *Esox americanus* | 1-2-3 |
| **Green sunfish** | WIDE | 47 | *Lepomis cyanellus* | 1-2-3 |
| **Greenside darter** | O | 49 | *Ehtheostoma blennioides* | 1-2-3 |
| **Hornyhead chub #** | O | 84 | *Nocomis biguttatus* | 1-2-3 |
| **Lake chubsucker** | L | - | *Erimyzon succetta* | 1*-2*-3* |
| **Largemouth bass** | WIDE | 29 | *Micropterus salmoides* | 1-2-3 |
| **Largescale stoneroller #** | O | 69 | *Campostoma oligolepis* | 1-2-3 |
| **Larval lamprey** | O | 8 | *Ichthyomyzon ammocoete* | 2-3 |
| **Least brook lamprey** | O | 14 | *Lampetra aepyptera* | 2 |
| **Longear sunfish** | L,O | 49 | *Lepomis megalotis* | 1-2-3 |
| **Longnose gar** | WIDE | 3 | *Lepisosteus osseus* | 3 |
| **Northern hogsucker #** | O | 55 | *Hypentelium nigricans* | 1-2-3 |
| **Orangethroat darter** | O,P | 71 | *Etheostoma spectabile* | 1-2-3 |
| **Northern studfish** | O | 63 | *Fundulus catenatus* | 1-2-3 |
| **Ohio logperch** | O | 16 | *Percina c. caprodes* | 1-2-3 |
| **Ozark bass** | O | 35 | *Ambloplites constellatus* | 1-2-3 |
| **Ozark chub** | O | 6 | *Erimystax harryi* | 2-3 |
| **Ozark madtom** | O | 29 | *Noturus albater* | 1-2-3 |
| **Ozark minnow** | O | 71 | *Notropis nubilus* | 1-2-3 |
| **Ozark sculpin** | O | 75 | *Cottus hypselurus* | 1-2-3 |
| **Ozark shiner** | O | 16 | *Notropis ozarcanus* | 1-2-3 |
| **Rainbow darter** | O | 80 | *Etheostoma caeruleum* | 1-2-3 |
| **Rainbow trout** | O | 10 | *Oncorynchus mykiss* | 2-3 |
| **Redear sunfish** | O | 4 | *Lepomis microlophus* | 2-3* |

| Common Name | Geo Affinity[1] | Percent Occurrence[2] | Scientific Name | Sam.[3] Date |
|---|---|---|---|---|
| **Redspotted sunfish** | L,O | 2 | *Lepomis miniatus* | 3 |
| **River Redhorse** | O | - | *Moxostoma carinatum* | 3 |
| **Rosyface shiner #** | O | 43 | *Notropis rubellus* | 1-2-3 |
| **Shorthead redhorse** | O | 8 | *Moxostoma macrolepidotum* | 2 |
| **Slender madtom #** | O | 41 | *Noturus exilis* | 1-2-3 |
| **Smallmouth bass #** | O | 43 | *Micropterus dolomieui* | 1-2-3 |
| **Southern redbelly dace #** | O | 61 | *Phoxinus erythrogaster* | 1-2-3 |
| **Spotted bass** | O,L | 4 | *Micropterus punctulatus* | 1-2-3* |
| **Steelcolor shiner #** | O | 2 | *Cyprinella whipplei* | 1 |
| **Stippled darter** | O | 35 | *Etheostoma punctulatum* | 1-2-3 |
| **Striped bass** | R | - | *Morone saxatilis* | 3* |
| **Striped fantail darter** | O | 25 | *Etheostoma f. lineolatum* | 1-3 |
| **Striped shiner #** | O | 59 | *Luxilus chrysocephalus* | 1-2-3 |
| **Telescope shiner** | O | 61 | *Notropis telescopus* | 1-2-3 |
| **Threadfin shad** | R | - | *Dorosoma petenense* | 2*-3* |
| **Walleye #** | O,R | 2 | *Stizostedion vitreum* | 1-3* |
| **Warmouth** | L | 2 | *Lepomis gulosis* | 3 |
| **White Bass** | O,P | - | *Morone chrysops* | 3* |
| **Wedgespot shiner** | O | 25 | *Notropis greenei* | 1-3 |
| **Western mosquitofish** | WIDE | 2 | *Gambusia affinis* | 3 |
| **White crappie** | WIDE | - | *Pomoxis annularis* | 3* |
| **White River Saddled Darter** | O | 8 | *Etheostoma e. euzonum* | 1-2-3 |
| **Whitetail shiner** | O | 20 | *Cyprinella galactura* | 1-2-3 |
| **Yellow bullhead** | O,P | 16 | *Ameirus natalis* | 1-2-3 |
| **Yoke darter** | O | 24 | *Etheostoma juliae* | 1-2-3 |

| Common Name | Geo Affinity[1] | Percent Occurrence[2] | Scientific Name | Sam.[3] Date |
|---|---|---|---|---|
| **Duskystripe shiner X southern redbelly dace** | | 2 | *Luxilus pilsbryi X Phoxinus erythrogaster* | 2 |
| **Green sunfish X bluegill** | | 6 | *Lepomis cyanellus X Lepomis macrochirus* | 1-3 |
| **Hornyhead chub X Duskystripe shiner** | | 2 | *Nocomis biguttatus X Luxilus pilsbryi* | 2 |
| **Ozark minnow X duskystripe shiner** | | 8 | *Notropis nubilus X Luxilus pilsbryi* | 1-3 |
| **Ozark minnow X Striped shiner** | | 2 | *Notropis nubilus X Luxilus chrysocephalus* | 3 |
| **White Bass X Striped Bass** | | - | *Norone chrysops X Morone saxatilis* | 3 |
| **Striped Shiner X duskystriped shiner** | | 2 | *Luxilus chrysocephalus X Luxilus pilsbryi* | 3 |

Table Bc02. Fish species distribution within the 11 digit hydrologic units of the North Fork (1 of 4) Watershed MDC Ozark Regional Fish Collection Files; MDC 1998a). Exclusive of data which is not in the previously cited sources. Note: List does not include "species of conservation concern".

| Common Name | Scientific Name | UB | LB | WNL | ENL | LNF | UNF |
|---|---|---|---|---|---|---|---|
| **Banded darter** | *Etheostoma zonale* | X | X | X | | X | X |
| **Banded sculpin** | *Cottus carolinae* | X | X | X | X | X | X |
| **Bigeye chub** | *Notropis amblops* | X | X | X | | X | |
| **Bigeye shiner** | *Notropis boops* | X | X | X | | X | |
| **Black crappie** | *Pomoxis nigromaculatus* | X | | | | X | X |
| **Black bullhead** | *Ameirus melas* | X | | X | | X | X |
| **Black redhorse** | *Moxostoma duquesnei* | X | | X | | X | X |
| **Black spotted topminnow** | *Fundulus olivaceus* | X | X | X | X | X | X |
| **Bluegill** | *Lepomis macrochirus* | X | | X | X | X | X |
| **Bluntnose minnow** | *Pimepales notatus* | X | | X | | X | X |
| **Brook silverside** | *Labidesthes sicculus* | | X | X | | | |
| **Brown trout** | *Salmo trutta* | X | | | | X | |
| **Central stoneroller** | *Campostoma pullum* | X | X | X | X | X | X |
| **Chain pickerel** | *Esox niger* | | | | | X | |
| **Channel catfish** | *Ictalurus punctatus* | | | X | | X | |
| **Chestnust Lamprey** | *Ichthyomyzon castaneus* | X | | | | X | |
| **Common carp** | *Cyprinus carpio* | | | | | X | |
| **Creek chub** | *Semotilus atromaculatus* | X | X | | | X | X |
| **Creek chubsucker** | *Erimyzon oblongus* | X | X | | | X | X |
| **Duskystripe** | *Luxilus pilsbryi* | X | X | X | X | X | X |

| Common Name | Scientific Name | UB | LB | WNL | ENL | LNF | UNF |
|---|---|---|---|---|---|---|---|
| **Shiner** | | | | | | | |
| **Flathead catfish** | *Pylodictis olivaris* | | | X | | | |
| **Gilt darter** | *Percina evides* | | | X | | | |
| **Gizzard shad** | *Dorosoma cepedianum* | X | | | | | |
| **Golden redhorse** | *Moxostoma erythrurum* | | | X | | X | X |
| **Golden shiner** | *Notemigonus crysoleucas* | | | | | | |
| **Grass Pickerel** | *Esox americanus* | X | | | | X | X |
| **Green sunfish** | *Lepomis cyanellus* | X | X | X | X | X | X |
| **Greenside darter** | *Ehtheostoma blennioides* | X | X | X | X | X | X |
| **Hornyhead chub** | *Nocomis biguttatus* | X | X | X | X | X | X |
| **Largemouth Bass** | *Micropterus salmoides* | X | | X | X | X | X |
| **Largescale stoneroller** | *Campostoma oligolepis* | X | X | X | X | X | X |
| **Larval lamprey** | *Ichthyomyzon ammocoete* | X | X | | | | |
| **Least brook lamprey** | *Lampetra aepyptera* | X | | | | X | X |
| **Longear sunfish** | *Lepomis megalotis* | X | X | X | X | X | X |
| **Longnose gar** | *Lepisosteus osseus* | | | X | | X | |
| **Northern hogsucker** | *Hypentelium nigricans* | X | X | X | X | X | X |
| **Orangethroat darter** | *Etheostoma spectabile* | X | X | | X | X | X |
| **Northern studfish** | *Fundulus catenatus* | X | X | X | X | X | |
| **Ohio logperch** | *Percina c. caprodes* | | | X | | X | X |

| Common Name | Scientific Name | UB | LB | WNL | ENL | LNF | UNF |
|---|---|---|---|---|---|---|---|
| **Ozark bass** | *Ambloplites constellatus* | X | | X | | X | X |
| **Ozark chub** | *Erimystax harryi* | | | X | | | X |
| **Ozark madtom** | *Noturus albater* | X | X | X | X | X | |
| **Ozark minnow** | *Notropis nubilus* | X | X | X | X | X | X |
| **Ozark sculpin** | *Cottus hypselurus* | X | X | X | | X | X |
| **Rainbow darter** | *Etheostoma caeruleum* | X | X | X | X | X | X |
| **Rainbow trout** | *Oncorynchus mykiss* | X | X | | | X | |
| **Redear sunfish** | *Lepomis microlophus* | | | | | X | |
| **Redspotted sunfish** | *Lepomis miniatus* | X | | | | | |
| **Rosyface shiner** | *Notropis rubellus* | X | X | X | | X | X |
| **Shorthead redhorse** | *Moxostoma macrolepidotum* | | | | | X | |
| **Slender madtom** | *Noturus exilis* | X | | X | X | X | X |
| **Smallmouth bass** | *Micropterus dolomeieui* | X | X | X | X | X | X |
| **Southern redbelly dace** | *Phoxinus erythrogaster* | X | X | X | | X | X |
| **Spotted bass** | *Micropterus punctulatus* | | | X | | X | |
| **Steelcolor shiner** | *Cyprinella whipplei* | | | X | | | |
| **Stippled darter** | *Etheostoma punctulatum* | X | | X | | X | X |
| **Striped bass** | *Morone saxatillis* | | | | | | |
| **Striped fantail darter** | *Etheostoma f. lineolatum* | X | | X | | X | X |
| **Striped shiner** | *Luxilus chrysocephalus* | X | | X | X | | X |

| Common Name | Scientific Name | UB | LB | WNL | ENL | LNF | UNF |
|---|---|---|---|---|---|---|---|
| **Telescope shiner** | *Notroopis telescopus* | X | X | | X | X | X |
| **Walleye** | *Stizostedion vitreum* | | | X | | | |
| **Warmouth** | *Lepomis gulosis* | X | | | | | |
| **White Bass** | *Morone chrysops* | | | | | | |
| **Wedgespot shiner** | *Notroppis greenei* | X | X | X | | X | X |
| **Western mosquitofish** | *Gambusia affinis* | | | | X | | |
| **White crappie** | *Pomoxis annularis* | | | | | | |
| **White River Saddled Darter** | *Etheostoma e. euzonum* | X | | X | | X | X |
| **Whitetail shiner** | *Cyprinella galactura* | X | X | X | | X | X |
| **Yellow bullhead** | *Ameirus natalis* | X | | X | | X | X |
| **Yoke darter** | *Etheostoma juliae* | X | X | X | X | X | X |

**UB**=Upper Bryant **LB**=Lower Bryant **WNL**=West Norfork Lake
**ENL**=East Norfork Lake **LNF**=Lower North Fork **UNF**=Upper North Fork

Table Bc03. Freshwater mussel species found within the North Fork Watershed in Missouri (1=Oesch 1995, 2=Buchanan 1996, 3=MDC 1998b, Turgeon 1998).

| Common Name | Scientific Name | Source |
|---|---|---|
| **Arkansas Broken-ray** | *Lampsilis r. reeviana* | 1,2,3 |
| **Asian Clam** | *Corbicula fluminea* | 1,3 |
| **Bleedingtooth Mussel** | *Venustaconcha pleasi* | 1,2,3 |
| **Creeper** | *Strophitus undulatus* | 1,3 |
| **Elktoe** | *Alasmidonta marginata* | 1,3 |
| **Fatmucket** | *Lampsilis siliquoidea* | 3 |
| **Fluted Shell** | *Lasmigona costata* | 1,3 |
| **Lilliput** | *Toxolasma parvus* | 1 |
| **Little Spectaclecase** | *Villosa lienosa* | 3 |
| **Northern Broken-ray** | *Lampsilis r. brittsi* | 3 |
| **Ouachita Kidneyshell** | *Ptychobranchus occidentalis* | 1,2,3 |
| **Ozark Pigtoe** | *Fusconaia ozarkensis* | 1,2,3 |
| **Ozark Broken-ray** | *Lampsilis r. brevicula* | 1,2,3 |
| **Plain Pocketbook** | *Lampsilis cardium* | 1,3 |
| **Purple Lilliput** | *Toxolasma lividus* | 1,2,3 |
| **Purple Wartyback** | *Cyclonaias tuberculata* | 1,3 |
| **Rainbow** | *Villosa iris* | 1,2,3 |
| **Round Pigtoe** | *Pleurobema sintoxia* | 3 |
| **Slippershell Mussel** | *Alasmidonta viridis* | 1,2,3 |
| **Spike** | *Eliptio dilatata* | 1,3 |
| **Wabash Pigtoe** | *Fusconaia flava* | 3 |

Table Bc04. Freshwater snail species found within the North Fork Watershed in Missouri (Wu etal. 1997).

| Scientific Name | Common Name |
|---|---|
| ***Campeloma subsolidum*** | highland campeloma |
| ***Elimia potosiensis*** | pyramid elimia |
| ***Ferrissia rivularis*** | creeping ancylid |
| ***Helisoma ancepes*** | two-ridge rams-horn |
| ***Helisoma triroluis*** | marsh ramshorn |
| ***Leptoxis arkansensis*** | Arkansas mudalia |
| ***Menetus dilatatus*** | bugle sprite |
| ***Physa acuta*** | lateritic physa |
| ***Physa (physella) goodrichi*** | Goodrich's physa |
| ***Physa gyrina*** | tadpole physa |
| ***Physa (Physodon) halei*** | Hales physa |
| ***Physa (Physodon) pomilia*** | glossy physa |
| ***Pleurocera acuta*** | sharp hornsnail |
| ***Pomatiopsis lapidaria*** | slender walker |
| ***Pyrgulopsis ozarkensis*** | Ozark pyrg |

Table Bc05. List of aquatic invertebrates collected by Duchrow 1974-1976 within the North Fork Watershed (MDC 1998d). Stream abbreviations are as follows: B=Bryant Creek, CS=Crystal Spring, H=Hunter Creek, WH=Watered Hollow.

| Order | Family | Species | Stream | | | |
|---|---|---|---|---|---|---|
| | | | B | CS | H | WH |
| **Amphipoda** | Gammaridae | *Gammarus pseudolimnaeus* (Bousfield) | X | X | X | |
| **Amphipoda** | Talitridae | *Hyalella azteca* (Saussure) | | X | | |
| **Coleoptera** | Dryopidae | *Dryops sp.* | | | | X |
| **Coleoptera** | Dytiscidae | *Dytiscus sp.* | X | X | | |
| **Coleoptera** | Elmidae | *Dubiraphia bivittata* (LeConte) | X | | | |
| **Coleoptera** | Elmidae | *Optioservus sandersoni* (Collier) | X | X | X | |
| **Coleoptera** | Elmidae | *Stenelmis sp.* | X | X | X | |
| **Coleoptera** | Psephinidae | *Ectopria nervosa* (Melsheimer) | X | X | X | |
| **Coleoptera** | Psephinidae | *Psephenus herricki* (DeKay) | X | X | X | X |
| **Coleoptera** | | | X | | | |
| **Decapoda** | Cambaridae | *Cambarus hubbsi* (Creaser) | X | X | | |
| **Decapoda** | Cambaridae | *Orconectes marchandi* (Hobbs) | X | X | X | X |
| **Decapoda** | Cambaridae | *Orconectes macrus* (Williams) | X | | | |
| **Diptera** | Athericidae | *Atherix lantha* (Webb) | X | | | |
| **Diptera** | Ceratopogonidae | *Bezzia/Probezzia...* | X | X | X | |
| **Diptera** | | *Ceratopogonidae* | X | X | X | |
| **Diptera** | | *Chironomidae* | X | X | X | X |
| **Diptera** | | *Empididae* | X | X | X | X |
| **Diptera** | | *Muscidae* | X | | | |
| **Diptera** | Stratiomyidae | | X | X | X | X |
| **Diptera** | | | X | X | X | |
| **Diptera** | Tabanidae | | X | | X | |
| **Diptera** | Tanyderidae | *Protoplasa fitchii* (Osten-Sacken) | X | | | |
| **Diptera** | Tipulidae | *Hexatoma sp.* | X | | X | X |

| Order | Family | Species | Stream | | | |
|---|---|---|---|---|---|---|
| | | | B | CS | H | WH |
| **Diptera** | Tipulidae | *Antocha sp.* | X | | | |
| **Diptera** | Tipulidae | *Erioptera sp.* | X | X | | |
| **Diptera** | Tipulidae | *Tipula sp.* | X | X | X | |
| **Diptera** | Tipulidae | *Tipulidae* | X | | | |
| **Ephemeroptera** | Baetidae | *Acentrella sp.* | X | X | X | X |
| **Ephemeroptera** | Baetidae | *Baetis tricaudatus* (Dodds) | X | X | X | X |
| **Ephemeroptera** | Caenidae | *Caenis sp.* | X | X | X | |
| **Ephemeroptera** | Ephemerellidae | *Ephemerella (invaria grp.)* | X | X | | |
| **Ephemeroptera** | Ephemerellidae | *Eurylophella (bicolor grp.)* | X | X | X | |
| **Ephemeroptera** | Heptageniidae | *Heptagenia sp.* | X | X | X | |
| **Ephemeroptera** | Heptageniidae | *Rhithrogena pellucida* (Daggy) | X | X | | |
| **Ephemeroptera** | Ephemerellidae | *Serratella sp.* | X | X | | |
| **Ephemeroptera** | Heptageniidae | *Stenacron gildersleevei* (Traver) | X | | X | X |
| **Ephemeroptera** | Heptageniidae | *Stenacron (interpunctatum grp.)* | X | | X | |
| **Ephemeroptera** | Heptageniidae | *Stenonema pulchellum (Walsh)* | X | | X | |
| **Ephemeroptera** | Heptageniidae | *Stenonema mediopunctatum (McDunnough)* | X | | X | |
| **Ephemeroptera** | Heptageniidae | *Stenonema femoratum* (Say) | | | X | X |
| **Ephemeroptera** | Isonychiidae | *Isonychia sp.* | X | | X | X |
| **Ephemeroptera** | Leptophlebiidae | *Paraleptophlebia moerens* (McDunnough) | X | | X | X |
| **Ephemeroptera** | Leptophlebiidae | | X | | X | X |
| **Ephemeroptera** | Tricorythidae | *Tricorythodes sp.* | X | | X | X |
| **Gordiida** | | | | | X | X |
| **Hemiptera** | Gerridae | *Gerris. Sp.* | | | | X |
| **Hemiptera** | Veliidae | | | | | X |
| **Hirudinea**[2] | | | | | X | X |
| **Hirudinea**[2] | Branchiobdellidae1 | | X | | | |

| Order | Family | Species | Stream | | | |
|---|---|---|---|---|---|---|
| | | | B | CS | H | WH |
| **Hydracarina** | Acari | | X | X | X | X |
| **Isopoda** | Asellidae | *Caecidotea sp.* | X | | X | X |
| **Isopoda** | Asellidae | *Lirceus sp.* | X | X | X | X |
| **Lepidoptera** | Pyralidae | *Petrophila sp.* | | | X | |
| **Lepidoptera** | Pyralidae | *Schoenobius sp.* | | | X | |
| **Lymnophila** | Physidae | | X | | X | X |
| **Lymnophila** | Planorbidae | | X | | | |
| **Megagastropoda** | Pleuroceridae | *Elimia potosiensis plebeius* (Gould) | X | | X | |
| **Megaloptera** | Corydalidae | *Corydalus cornutus* (Linnaeus) | X | | X | |
| **Megaloptera** | Corydalidae | *Nigronia serricornis* (Say) | X | | X | X |
| **Megaloptera** | Sialidae | *Sialis sp.* | | | X | |
| **Nemata3** | | | X | X | | X |
| **Odonata** | Calopterygidae | *Hetaerina americana* (Fabricius) | X | | | |
| **Odonata** | Calopterygidae | *Hetaerina sp.* | | | | X |
| **Odonata** | Coenagrionidae | | | | X | X |
| **Odonata** | Coenagrionidae | *Argia moesta* (Hagen) | | | X | |
| **Odonata** | Gomphidae | | | | X | X |
| **Oligochaeta** | | | | | X | X |
| **Plecoptera** | Capniidae | *Allocapnia sp.* | | | | X |
| **Plecoptera** | Capniidae | *Paracapnia sp.* | X | | X | X |
| **Plecoptera** | Chloroperlidae | | X | | X | X |
| **Plecoptera** | Chloroperlidae | *Alloperla sp.* | | | X | |
| **Plecoptera** | Chloroperlidae | *Alloperla caudata* (Frison) | | | X | |
| **Plecoptera** | Nemouridae | | X | | X | X |
| **Plecoptera** | Perlidae | *Acroneuria sp.* | X | | X | X |
| **Plecoptera** | Perlidae | *Paragnetina sp.* | X | | | |

| Order | Family | Species | Stream | | | |
|---|---|---|---|---|---|---|
| | | | B | CS | H | WH |
| **Plecoptera** | Perlidae | *Paragnetina media* (Walker) | X | | X | |
| **Plecoptera** | Perlidae | *Perlesta placida* (Hagen) | X | | X | X |
| **Plecoptera** | Perlidae | *Perlinella drymo* (Newman) | | | | X |
| **Plecoptera** | Perlidae | *Perlinella sp.* | | | X | |
| **Plecoptera** | Perlodidae | *Hydroperla sp.* | X | | X | X |
| **Plecoptera** | Perlodidae | *Isoperla mohri* (Frison) | X | | X | X |
| **Plecoptera** | Perlodidae | *Isoperla bilineata* (Say) | X | | X | X |
| **Plecoptera** | Perlodidae | *Isoperla marlynia* (Needham & Claassen) | | | | X |
| **Plecoptera** | Perlodidae | *Isoperla sp.* | | | | X |
| **Plecoptera** | Pteronarcyidae | *Pteronarcys sp.* | | | X | |
| **Plecoptera** | Pteronarcyidae | *Pteronarcys pictetii* (Hagen) | X | | X | |
| **Plecoptera** | Taeniopterygidae | *Strophopteryx fasciata* (Burmeister) | X | | X | |
| **Trichoptera** | Brachycentridae | *Brachycentrus americanus* (Banks) | X | | | X |
| **Trichoptera** | Glossosomatidae | *Agapetus sp.* | X | | X | X |
| **Trichoptera** | Helicopsychidae | *Helicopsyche borealis* (Hagen) | X | | X | X |
| **Trichoptera** | Hydropsychidae | *Ceratopsyche (morosa grp.)* | X | | X | X |
| **Trichoptera** | Hydropsychidae | *Ceratopsyche piatrix* (Ross) | X | | X | X |
| **Trichoptera** | Hydropsychidae | *Cheumatopsyche sp.* | X | X | X | X |
| **Trichoptera** | Hydropsychidae | *Hydropsyche cuanis* (Ross) | | | | X |
| **Trichoptera** | Hydropsychidae | *Hydropsyche betteni* (Ross) | | | | X |
| **Trichoptera** | Hydroptilidae | *Agraylea multipunctata Curtis* | X | X | X | X |
| **Trichoptera** | Hydroptilidae | *Ochrotrichia sp.* | | | X | |
| **Trichoptera** | Hydroptilidae | *Orthotrichia sp.* | | | | X |
| **Trichoptera** | Philopotamidae | *Chimarra aterrima* (Hagen) | X | | X | X |
| **Trichoptera** | Philopotamidae | *Chimarra obscura* (Walker) | X | | X | |
| **Trichoptera** | Polycentropodidae | *Polycentropus sp.* | X | | X | X |

| Order | Family | Species | Stream | | | |
|---|---|---|---|---|---|---|
| | | | B | CS | H | WH |
| **Trichoptera** | Rhyacophilidae | | X | | X | X |
| **Tricladida** | Planariidae | | X | X | X | X |
| **Veneroida** | Sphaeriidae | | | | X | |

[1]Subclass, [2]Class, [3]Phylum

Table Bc06. Species of conservation concern within the North Fork Watershed (Oesch 1995; Buchanan 1996; MDC 1998b; MDC 1999b; MDC 1999e; and Bruenderman, personal communication).

| Scientific Name | Common Name | Federal Status | State Status | G rank | S rank |
|---|---|---|---|---|---|
| **Mammals** | | | | | |
| ***Felis concolor*** | Mountain Lion | | E | G5 | SU |
| ***Lepus californicus*** | Black-tailed Jackrabbit | | E | G5 | S1 |
| ***Myotis grisescens*** | Gray Bat | E | E | G3 | S3 |
| ***Myotis septentrionalis*** | Northern Myotis | | | G4 | S3 |
| ***Myotis sodalis*** | Indiana Bat | E | E | G2 | S1 |
| **Birds** | | | | | |
| ***Accipiter cooperii*** | Cooper's Hawk | | | G5 | S3 |
| ***Aimophila aestivalis*** | Bachman's Sparrow | * | E | G3 | S1 |
| ***Ardea herodias*** | Great Blue Heron | | | G5 | S5 |
| ***Haliaeetus leucocephalus*** | Bald Eagle | T | E | G4 | S2 |
| ***Limnothlypis swainsonii*** | Swainson's Warbler | | E | G4 | S1 |
| **Reptiles** | | | | | |
| ***Crotaphytus c. Collaris*** | Eastern Collared Lizard | | | G5 | S4 |
| ***Macroclemys temminckii*** | Alligator Snapping Turtle | * | | G3G4 | S2 |
| **Amphibians** | | | | | |
| ***Cryptobranchus alleganiensis bishopi*** | Ozark Hellbender | * | | G4T3 | S2 |
| **Fish** | | | | | |
| ***Erimyzon sucetta*** | Lake Chubsucker | | | G5 | S2 |
| ***Notropis ozarcanus*** | Ozark Shiner | * | | G3 | S2 |
| ***Notorus flavater*** | Checkered Madtom | | | G4 | S3S4 |
| **Invertebrates** | | | | | |

| Scientific Name | Common Name | Federal Status | State Status | G rank | S rank |
|---|---|---|---|---|---|
| ***Amblytropidia mysteca*** | A Glade Grasshopper | | | G? | SU |
| ***Pardalophora saussurei*** | A Glade Grasshopper | | | G? | S3 |
| ***Alasmidonta marginata*** | Elktoe (mussel) | * | | G4 | S2? |
| ***Lampsilis r. reeviana*** | Arkansas Broken-ray (mussel) | | | G3T1 T2 | S2? |
| ***Leptoxis arkansensis*** | Arkansas Mudalia (snail) | | | G? | SU |
| ***Ptychobranchus occidentalis*** | Ouachita Kidneyshell (mussel) | * | | G3G4 | S2S3 |
| ***Pyrgulopsis ozarkensis*** | Ozark Pyrg (snail) | | | G1? | SU |
| ***Toxolasma lividus*** | Purple Lilliput (mussel) | * | | G2 | S2? |
| | | **Plants** | | | |
| ***Agalinis skinneriana*** | Pale Gerardia | * | | G3 | S3 |
| ***Agrimonia gryposepala*** | Tall Agrimony | | | G5 | SU |
| ***Amsonia ciliata var. filifolia*** | Ciliate Bllue Star | | | G5?T4? | S2S3 |
| ***Aster furcatus*** | Forked Aster | * | | | |
| ***Aster macrophyllus*** | Big-leaved Aster | | | G3 | S2 |
| ***Calamagrostis porteri ssp insperata*** | Reed Bent Grass | * | | G4T3 | S3 |
| ***Carex alata*** | Broadwing Sedge | | | G5 | S2S3 |
| ***Carex decomposita*** | Epiphytic Sedge | | | G3 | S3 |
| ***Carex stricta*** | Tussock Sedge | | | G5 | S2? |
| ***Carex fissa var. fissa*** | A Sedge | * | | G3G4 QT3? | S1 |
| ***Cheilanthes alabamensis*** | Alabama Lip-fern | | | G4G5 | S1 |
| ***Cissus incisa*** | Marine Vine | | | G4G5 | S2 |
| ***Clematis fremontii*** | Fremont's Leather Flower | | | G5 | S3 |

| Scientific Name | Common Name | Federal Status | State Status | G rank | S rank |
|---|---|---|---|---|---|
| ***Crataegus spathulata*** | A Hawthorn | | | G5 | SH |
| ***Cypripedium reginae*** | Showy Lady-slipper | | | G4 | S2S3 |
| ***Diarrhena americana var. americana*** | American Beakgrain | | | G4? | S1 |
| ***Dryopteris celsa*** | Log Fern | | | G4 | S1 |
| ***Encalypta procera*** | Extinguisher Moss | | | G4G5 | S1 |
| ***Eriogonum longifolium var. longifolium*** | Umbrella Plant | | | G4T4 | S2 |
| ***Filipendula rubra*** | Queen of the Prairie | | | G4G5 | S2 |
| ***Hydrocotyle verticillata var. verticillata*** | Water Pennywort | | | G5T5 | S1 |
| ***Kurzia setacea*** | A Liverwort | G4G5 G5?TU | S1 | | |
| ***Liatris scariosa var. nieuwlandii*** | A Blazing Star | | S2 | | |
| ***Malaxis unifolia*** | Green Adder's Mouth | | | G5 | S3 |
| ***Marshallia caespitosa var. signata*** | Barbara's Buttons | | | G4T4 | S1 |
| ***Metzgeria conjugata*** | A Liverwort | | | G5 | S1S2 |
| ***Mnium thomsonii*** | A Moss | | | G5 | S? |
| ***Nowellia curvifolia*** | A Liverwort | | | G5 | S? |
| ***Phlox bifida ssp. stellaria*** | Bifid Phlox | | | G5?T3 | S1 |
| ***Potamogeton pusillus var. pusillus*** | Slender Pondweed | | | G5T5 | S1 |
| ***Preissia quadrata*** | A Liverwort | | | G5 | S? |
| ***Ptychomitrium sinense*** | A Moss | | | G3?Q | S1 |
| ***Rhynchospora harveyi*** | Harvey's Beak-rush | | | G4 | S1 |
| ***Rhytidiadelphus triquetrus*** | Shaggy Moss | | | G5 | S? |

| Scientific Name | Common Name | Federal Status | State Status | G rank | S rank |
|---|---|---|---|---|---|
| ***Sullivantia sullivantii*** | Sullivantia | | | G4 | S2 |
| ***Tradescantia ozarkana*** | Ozark Spiderwort | * | | G3 | S2 |
| ***Trifolium stoloniferum*** | Running Buffalo Clover | E | E | G3 | S1 |
| ***Waldsteinia fragarioides ssp. fragarioides*** | Barren Strawberry | | | G5T5 | S2 |
| ***Wolffia punctata*** | Dotted Water-meal | | | G5 | SU |
| ***Yucca arkansana*** | Arkansas Yucca | | | G5 | S2 |
| ***Zigadenus elegans*** | White Camas | | | G5 | S2 |

### Federal Status

E=Endangered

T=Threatened

* =Former category-2 candidate (In December of 1996, the USFWS discontinued the practice of maintaining a list of species regarded as "category-2 candidates". MDC continues to distinguish these species for information and planning purposes.

### State Status

E=Endangered

### Srank

S1=Critically imperiled in the state because of extreme rarity or because of some factor(s) making it especially vulnerable to extirpation from the state. (typically 5 or fewer occurrences or very few remaining individuals)

S2=Imperiled in the state because of rarity or because of some factor(s) making it very vulnerable to extirpation from the state. (6 to 20 occurrences or few remaining individuals or acres)

S3=Rare and uncommon in the state. (21 to 100 occurrences)

S4=Widespread, abundant, and apparently secure in state, with many occurrences, but the species is of long-term concern. (usually more than 100 occurrences)

S5=Demonstrably widespread, abundant, and secure in the state, and essentially ineradicable under present conditions.

SU=Unrankable: Possibly in peril in the state, but status uncertain; need more information. SE=Exotic: An exotic established in the state; may be native in nearby regions.

SH=Historical: Element occurred historically in the state (with expectation that it may be rediscovered). Perhaps having not been verified in the past 20 years, and suspected to be still extant.

S?=Unranked: Species is not yet ranked in the state.

### Qualifier:

? =Inexact or uncertain: for numeric ranks, denotes inexactness. (The ? qualifies the character

immediately preceding it in Srank)

Q=Questionable taxonomy: taxonomic status is questionable; numeric rank may change with taxonomy.

### *GRank*

G2=Imperiled globally because of rarity or because of some factor(s) making it very vulnerable to extinction throughout its range. (6 to 20 occurrences or few remaining individuals or acres)

G3=Either very rare and local throughout its range or found locally (even abundantly at some of its locations) in a restricted range (e.g., a single western state, a physiographic region in the East) or because of other factors making it vulnerable to extinction throughout its range. (21 to 100 occurrences)

G4=Widespread, abundant, and apparently secure globally, though it may be quite rare in parts of its range, especially at the periphery. Thus, the element is of long-term concern. (usually more than 100 occurrences)

G5=Demonstrably Widespread, abundant, and secure globally, though it may be quite rare in parts of its range, especially at the periphery.

### *Subrank:*

T=Taxonomic subdivision: rank applies to subspecies or variety.

**Note:** Data in table subject to revision. This table is not a final authority.

# Management Problems and Opportunities

The management goals, objectives, and strategies for the North Fork Watershed were developed using information collected from the North Fork Watershed Assessment and Inventory (WAI) and direction provided by the Missouri Department of Conservation (MDC) Strategic Plan, and the Ozark Region Management Guidelines. Objectives and strategies were written for instream and riparian habitat, water quality, aquatic biota, recreational use, and hydrography. All goals are of equal importance, with objectives listed in prioritized order whenever possible. This plan includes only those activities and results the Missouri Department of Conservation can reasonably expect to achieve or influence during the next 25 years. Completion of these objectives will depend upon their status in overall regional and division priorities and the availability of human resources and funds.

## Goal I: Improve riparian and aquatic habitats in the North Fork watershed.

**Status:** Problems affecting riparian and aquatic habitats include insufficient wooded riparian corridors, stream bank erosion, gravel dredging, and other point and non-point sources of pollution. Protecting and enhancing the riparian corridor is essential to obtaining quality aquatic habitats. A forested stream corridor substantially influences many components of the stream ecosystem including stream bank stability, water quality, ground water absorption and recharge to the stream, amount of physical instream habitat, spatial and structural complexity of physical instream habitat, and the food web.

### Objective 1.1: With the assistance of willing landowners, over a 25-year period, increase by 50% the proportion of streams with a forested corridor width >100 feet and decrease by 75% the amount of stream bank lacking woody vegetative cover.

**Strategy:** Using the following list of prioritized eleven digit hydrologic units (developed through evaluations of riparian forest cover, land ownership, losing streams, unit size relative to the whole watershed, and presence of sensitive species (Figure Mp01)), direct our management efforts towards those watersheds of highest priority: (1) Upper Bryant, (2) Lower North Fork, (3) Lower Bryant, (4) Upper North Fork, (5) West Norfork Lake, (6) East Norfork Lake.

1. Using videotapes, field investigations, aerial photography, and satellite imagery, document and update the current and future conditions of riparian corridors and stream banks. Future projects such as the Missouri Resource Assessment Partnership Land Cover Classification need to be encouraged in order to ensure that adequate data is available that will allow efficient analysis of riparian conditions over time.
2. Initial riparian corridor restoration efforts on public land should be guided by preestablished priorities set forth in table 4.2 of the Ozark Region Management Guidelines with later efforts based on area specific riparian corridor inventories.
3. Utilizing state and federal assistance programs, such as the MDC-DNR incentive programs and educational efforts, implement riparian and aquatic habitat protection measures on streams in cooperation with the Missouri Department of Conservation Private Land Services Division and willing private
4. Using current knowledge of the effects of instream gravel removal, continue to work closely with gravel operators and other appropriate government agencies to limit the negative impacts of gravel removal.
5. Continue to assist appropriate state and federal agencies in the enforcement of existing water quality laws in regard to gravel removal.
6. Assist with additional research efforts regarding the effects of instream gravel removal in order to develop measures that adequately protect aquatic resources.

## Goal II: Improve surface and ground water quality in the North Fork watershed

**Status:** Water quality within the watershed is relatively good. However, periodic high fecal coliform levels, nutrient loading, and sediment and gravel deposition are the most severe threats to water quality. Gravel dredging, large numbers of livestock in riparian zones for extended periods of time, private septic system failure, increased nutrients from municipal sewage treatment facilities and poor land use practices such as indiscriminate land clearing, and development in riparian zones are the primary water quality concerns.

### *Objective 1.1: Assure that watershed streams meet or exceed state standards for water quality.*

**Strategy:** Due to the connection between the surface water and ground water systems in the watershed, protection of surface waters, both permanent and intermittent, can also greatly contribute to the enhancement of ground water quality. Protecting riparian corridors will reduce surface runoff and provide stream bank and channel stability. Streams also need protection from other pollutants. Education of the citizenry and landowners on water quality issues and land stewardship is the best hope for improving water quality. Encouragement of appropriate agencies to enforce existing water quality laws is also required to obtain satisfactory water quality.

1. Through media contacts, personal contacts, literature development, and speaking engagements to groups such as area Stream Teams and landowners, inform the public of water quality issues and problems (e.g. karst topography, excessive siltation, animal waste runoff, gravel dredging, septic system failure etc.) and potential solutions to these problems.
2. Establish a structured water quality sampling program within the watershed in cooperation with the Missouri Department of Natural Resources and Stream Teams. Priority should be given to public areas within the watershed; specifically, those listed in table 4.3 of the Ozark Regional Management Guidelines.
3. Establish fish and mussel contaminant sampling locations throughout the watershed.
4. Assist with training and involvement of Stream Teams in water quality monitoring and advocacy in the watershed.
5. Encourage and assist with additional dye tracing studies within the watershed in order to further determine intrawatershed and interwatershed ground water movement as well as recharge area of selected springs within the watershed with an emphasis on publicly owned spring outlets.
6. Encourage and assist with enforcement of existing water quality laws by reviewing 404 permits, cooperating with other state and federal agencies to investigate pollution and fish kill reports, collecting water quality related data, and recommending measures to protect aquatic communities. Additional emphasis should be placed on losing streams.
7. Encourage the entry of water quality data into a Geographic Information System (GIS) compatible format in order to facilitate effective data updating and analysis. This includes the creation of a 'Designated Use' data layer based on current Rule 10 CSR 20-7.031 of the Rules of Department of Natural Resources Division 20-Clean Water Commission Chapter 7-Water Quality, Tables G and H.
8. Cooperate with other Missouri Department of Conservation divisions to insure all department areas follow best management practices.
9. In cooperation with district private lands services personnel, encourage limiting livestock access in riparian areas through education and/or incentive programs for private landowners.

## Goal III: Maintain the abundance, diversity, and distribution of aquatic biota at or above current levels while improving the quality of the sport fishery in the North Fork watershed.

**Status:** An assemblage of 76 fish species, 21 mussel species, 5 crayfish species, 15 snail species, and 106

taxa of benthic macro-invertebrates have been identified throughout the North Fork Watershed. A total of 65 "species of conservation concern" are known to occur in the watershed. This list includes three fish species; the lake chubsucker, Ozark Shiner, and checkered madtom and one species of amphibian: the Ozark Hellbender. In addition, 16 sport fish species occur within the watershed. These include grass pickerel, chain pickerel, rainbow trout, brown trout, Ozark bass, smallmouth bass, largemouth bass, spotted bass, channel catfish, flathead catfish, warmouth, walleye, black crappie, white crappie, striped bass, and white bass. Exotic aquatic species, other than some sport fish listed above, within the watershed include the Asian Clam and the common carp.

### *Objective 1.1: Maintain the diversity, abundance, and distribution of native non-sport fish and invertebrate communities at or above current levels.*

**Strategy:** High priority should be placed on protecting state and federally listed species and unique community assemblages. Focusing enhancement and protective efforts on a few species can be effective in helping other species that share the same habitat. Detecting changes in faunal composition and abundance can be accomplished by conducting routine surveys of fish and invertebrate communities.

1. Assist with recovery efforts for any state or federally-listed rare or endangered species in the watershed.
2. Survey fish communities in the watershed every 10 years at historical sampling sites using standardized sampling techniques. Establish additional sampling sites as necessary with high priority given to MDC areas. Incorporate data into a geographic information system (GIS) in order to facilitate documentation of changes in species diversity, abundance, and/or distribution.
3. Using GIS, document locations and identify unique fish assemblages associated with natural features and special habitats such as spring branches.
4. Assist in the development of criteria for identifying riparian and instream habitat needs (e.g., presence of species of conservation concern, extent of forested stream corridor, size of stream, land use, soils, presence of permanent water, presence of sport fish, natural features, critical habitat, etc.) and develop a prioritized list of streams and stream reaches needing habitat restoration with priority given to public lands.
5. If appropriate, initiate research projects in cooperation with Missouri Department of Conservation Research Staff to investigate reasons for significant changes in faunal abundance and distribution and recommend corrective measures.
6. Coordinate with MDC Research staff and other groups (i.e. University of Missouri, etc.) to develop a routine mussel survey schedule for the watershed.
7. Coordinate with MDC Research Staff and other groups (i.e., MDNR, University of Missouri, etc.) to conduct a survey of benthic invertebrates on all fifth order and larger streams. Resurvey every 10 years to document changes in species abundance, diversity, and distribution.

### *Objective 1.2: Maintain or improve populations of sport fish while maintaining a stable and diverse fish community.*

**Strategy:** Proper management of sport fish populations will depend on obtaining adequate samples to determine the status of the fishery and angler attitudes. Sport fish survey data for much of the North Fork River, and Bryant Creek is relatively current, however, insufficient data exists for the upper portion of Bryant Creek for setting specific management objectives. In addition, little recent angler survey data exists for cool water or warm water streams within the watershed. Once adequate information is obtained, future management efforts will be directed toward setting appropriate fishing regulations, protecting and improving fish habitat, and stocking where appropriate.

1. Develop and initiate a regular sampling regime for the upper portion of Bryant Creek to evaluate the status of its sport fish population and provide baseline data for management decisions.

2. In cooperation with MDC biometricians, develop and initiate angler surveys in order to determine the angler use and opinions regarding the cool-water and warm-water sport fishery within the watershed.
3. Implement stream habitat improvement projects in stream segments of heavy angler pressure which otherwise lack sufficient stream habitat.

### *Objective 1.3: Prevent detrimental impacts on native fauna of the North Fork Watershed by exotic aquatic species.*

**Strategy:** Controlling the introduction of exotic species into the state is the easiest way to prevent detrimental impacts to native fauna. Once a detrimental exotic species becomes established, research will be needed to seek ways to contain or eliminate it from the system.

1. Continue participation in the Missouri Aquaculture Advisory Council (MAAC) and other organizations and advocate controlling the introduction of exotic fauna into state waters.
2. Monitor for potentially harmful exotic species (i.e., zebra mussel or grass carp). This can be performed during fish community surveys.
3. Educate anglers on the potential damaging effects of 'bait bucket' introductions to lake and stream communities.
4. In cooperation with MDC Fisheries Research, MDC Protection Division, as well as other appropriate state and federal agencies, develop exotic species management plans in order to reduce or eliminate the negative impacts of exotic aquatic species such as the Asian Clam and common carp.

## Goal IV: Increase public awareness and promote wise use of aquatic resources in the North Fork watershed.

**Status:** Results from a statewide angler survey conducted from 1983 to 1986 indicated that an estimated average of 12,347 days annually were spent angling on the North Fork River and its tributaries. In addition, information from a 1991 and 1992 survey indicated substantial fishing activity occurs on the North Fork River within the section designated for cold-water sport fishery. Results indicated that angler visitation equaled an annual average 452 trips/mile per year and helped to generate more than half a million dollars for the local economy. Less is known regarding the current spatial distribution of total fishing pressure in the watershed. Canoeing is also a popular activity within the watershed. A relatively short term study of limited scope has been done regarding this type of recreation on a portion of the North Fork River, however additional information is needed in order to more adequately determine the extent of this use on the North Fork River as well as other major streams within the watershed.

### *Objective 4.1: Determine current spatial and seasonal distribution of aquatic oriented recreational pressure within the watershed.*

**Strategy:** In cooperation with appropriate state and/or federal agencies as well as private entities (i.e. river guides, canoe liveries) develop and implement methods to determine aquatic recreational use within the watershed.

1. In cooperation with MDC Biometrics Staff, develop angler survey methodology which allows the determination of spatial and temporal distribution of angler pressure within the watershed.
2. In cooperation with local canoe liveries and the United States Forest Service, develop a method of monitoring the spatial and temporal distribution of non-consumptive use of aquatic resources within the watershed (i.e. floating and swimming).
3. In cooperation with the MDC Biometrics Staff and the USFS, develop a continuous voluntary aquatic recreational use survey.

a. Establish survey stations at access sites. These would provide questionnaires, pencils, and a place to fill out the questionnaire.
b. Questionnaires would request non-personal information such as activity, number of persons, zip code, comments, etc.

### *Objective 4.2: Assure access sites are developed at desirable locations, and in numbers, to allow sufficient future public access to floating and fishing streams of the watershed.*

**Strategy:** Acquisition and development of additional stream frontage and access sites will do much to provide additional recreational opportunities throughout the watershed as well as provide showcases for Best Management Practices.

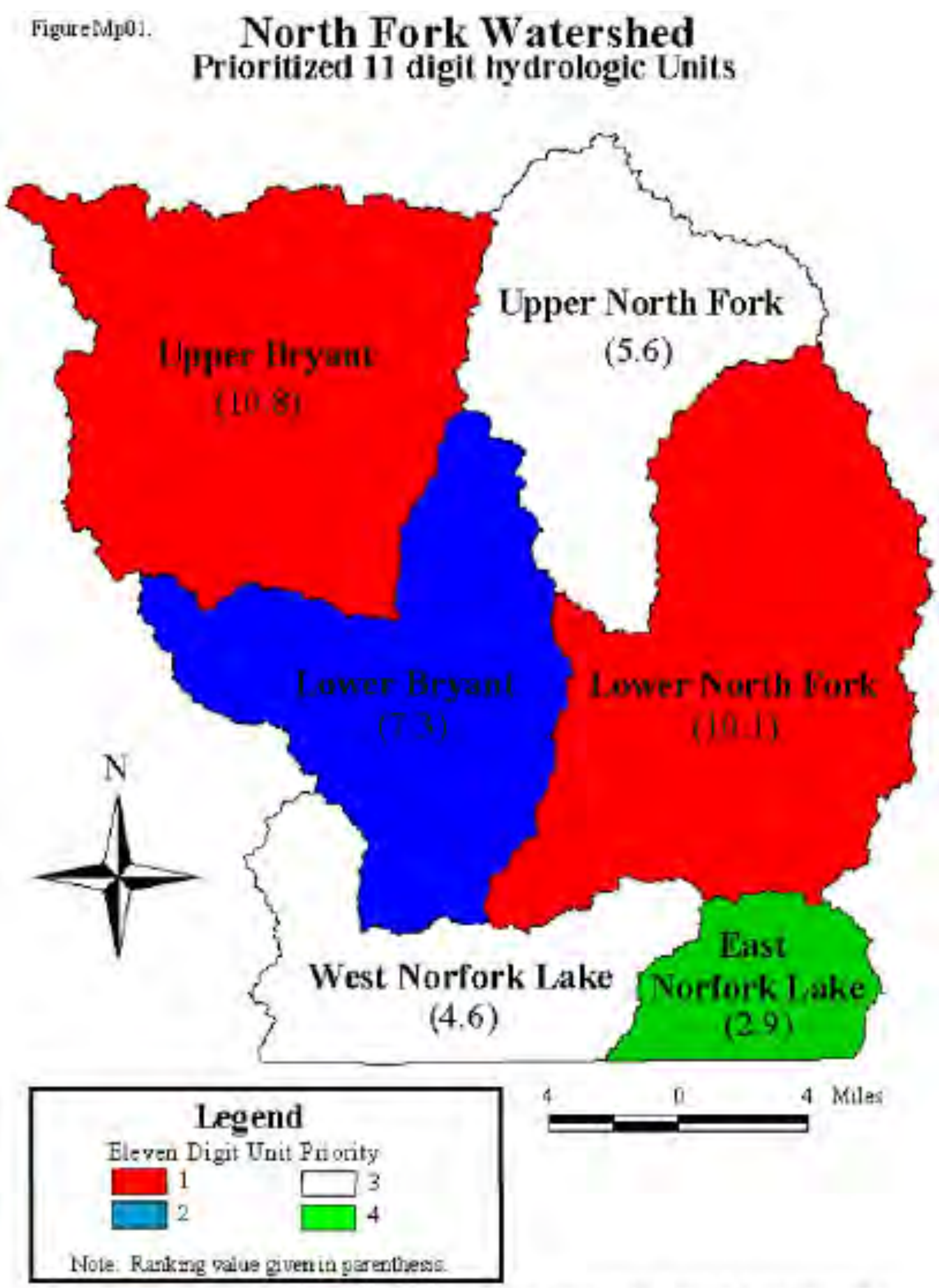
1. Using public input, intra and interagency input, as well as analysis of aquatic resource use patterns, assess future stream frontage and access needs within the watershed.
2. Pursue the acquisition of stream frontage sites based on need, availability, and site suitability in order to adequately provide for future public stream frontage needs.
3. Pursue the acquisition of stream access sites based on need, availability, and site suitability in order to adequately provide for future public stream access needs.

### *Objective 4.3: Increase awareness of stream recreational opportunities and appreciation of stream ecology and advocacy to a level that will encourage a widespread and diversified public interest in the North Fork Watershed.*

**Strategy:** Careful publicity which focuses on species of conservation concern as well as abundant local fish stocks can maintain and promote a continued appreciation of these different types of resource elements. Providing opportunities for the public to learn about holistic stream ecology should assist in creating stream advocates.

1. Write current fishing prospectus for public release to local media, describing the specific fisheries and angling opportunities of selected waters including both cold water, and cool/warm water fisheries as data becomes available.
2. Provide the local and statewide media with timely "How to", "When to" articles and interviews that focus attention on places as well as both consumptive (i.e. gigging, float/wade fishing) and
- non-consumptive activities (i.e. snorkeling, floating, underwater photography)
3. Publicize the acquisition, development and opening of new public access and/ stream frontage sites.
4. Conduct periodic recreational use surveys to determine levels of public use and satisfaction.
5. In cooperation with district private land services personnel, emphasize stream ecology and good stream stewardship (utilizing brochures, aquaria, and stream tables where applicable) during presentations to school groups, youth organizations, and private landowner contacts.
6. Conduct outdoor youth events, such as Ecology Days at stream sites with field activities that demonstrate stream ecology and good stream stewardship.
7. Facilitate the development and activity of Stream Teams and other groups interested in adopting or otherwise promoting good stewardship and enjoyment of watershed streams.
8. Provide promotional, educational, and technical stream materials to groups, fairs and other special events.
9. In cooperation with district private land services personnel, develop brochure which promotes best management practices within the watershed.
10. Ensure information provided within the Internet version of the watershed inventory and assessment is kept current.

Figure Mp01.




Ranking factor based on the following formula: ((((Rg+Rc+Ru)+P+Sp+Sl)/4)*(Au/Aw))+(S*0.1)
where:

Rg=Percent grassland riparian land use.
Rc=Percent cropland riparian land use
Ru=Percent urban riparian land use
P=Percent private land.
Sp=Ratio of Permanent Stream to Watershed Area (Sq. Miles)
Sl=Ratio of losing miles to watershed area (Sq. miles)
Au=Unit area
Aw=Watershed area
S=Number of Aquatic Oriented Animal Species of Conservation
Concern observed (only data from MDC natural heritage database used)

## Angler Guide

**Smallmouth bass** can be caught in good numbers upstream of the trout areas. Most of the fish will be less than 15". However, fish greater than 15" are not uncommon and fish greater than 17" have been caught. Jigs, crankbaits, and soft plastic baits fished around root wads and boulders account for the majority of these fish. **Ozark bass (goggle-eye)** are also abundant in this section of river and can be caught on the same type of lures as the smallmouth, but smaller versions of these lures will catch more fish. Downstream in the **Wild Trout Management Area (from Rainbow Spring to Blair Bridge),** anglers are required to fish with artificial lures only (no natural or soft plastic baits are permitted) and allowed to keep one trout 18" and larger. Poor natural reproduction has resulted in fewer rainbow trout than in past years, but **brown trout** numbers continue to remain at a level capable of supporting very good fishing. Wooly buggers and prince nymphs are good fly pattern choices. Also, crayfish and minnow imitating crankbaits as well as various spinners catch many fish in this area**.** The **Special Trout Management Area (from Blair Bridge to Norfork Lake)** contains good numbers of **brown trout** as well. Annually stocked brown trout provide anglers with plenty of action throughout this section of river. Anglers are allowed to fish with natural bait or artificial lures and keep up to three trout 15" and larger.

# Glossary

**Alluvial soil:** Soil deposits resulting directly or indirectly from the sediment transport of streams, deposited in river beds, flood plains, and lakes.

**Aquifer:** An underground layer of porous, water-bearing rock, gravel, or sand.

**Benthic:** Bottom-dwelling; describes organisms which reside in or on any substrate.

**Benthic macroinvertebrate:** Bottom-dwelling (benthic) animals without backbones (invertebrate) that are visible with the naked eye (macro).

**Biota:** The animal and plant life of a region.

**Biocriteria monitoring:** The use of organisms to assess or monitor environmental conditions.

**Channelization:** The mechanical alteration of a stream which includes straightening or dredging of the existing channel, or creating a new channel to which the stream is diverted.

**Concentrated animal feeding operation (CAFO):** Large livestock (ie. cattle, chickens, turkeys, or hogs) production facilities that are considered a point source pollution, larger operations are regulated by the MDNR. Most CAFOs confine animals in large enclosed buildings, or feedlots and store liquid waste in closed lagoons or pits, or store dry manure in sheds. In many cases manure, both wet and dry, is broadcast overland.

**Confining rock layer:** A geologic layer through which water cannot easily move.

**Chert:** Hard sedimentary rock composed of microcrystalline quartz, usually light in color, common in the Springfield Plateau in gravel deposits. Resistance to chemical decay enables it to survive rough treatment from streams and other erosive forces.

**Cubic feet per second (cfs):** A measure of the amount of water (cubic feet) traveling past a known point for a given amount of time (one second), used to determine discharge.

**Discharge:** Volume of water flowing in a given stream at a given place and within a given period of time, usually expressed as cubic feet per second.

**Disjunct:** Separated or disjoined populations of organisms. Populations are said to be disjunct when they are geographically isolated from their main range.

**Dissolved oxygen:** The concentration of oxygen dissolved in water, expressed in milligrams per liter or as percent.

**Dolomite:** A magnesium rich, carbonate, sedimentary rock consisting mainly (more than 50% by weight) of the mineral dolomite $(CaMg(CO_3)_2)$.

**Endangered:** In danger of becoming extinct.

**Endemic:** Found only in, or limited to, a particular geographic region or locality.

**Environmental Protection Agency (EPA):** A Federal organization, housed under the Executive branch, charged with protecting human health and safeguarding the natural environment — air, water, and land — upon which life depends.

**Epilimnion:** The upper layer of water in a lake that is characterized by a temperature gradient of less than $1^{\circ}$ Celsius per meter of depth.

**Eutrophication:** The nutrient (nitrogen and phosphorus) enrichment of an aquatic ecosystem that promotes biological productivity.

**Extirpated:** Exterminated on a local basis, political or geographic portion of the range.

**Faunal:** The animals of a specified region or time.

**Fecal coliform:** A type of bacterium occurring in the guts of mammals. The degree of its presence in a lake or stream is used as an index of contamination from human or livestock waste.

**Flow duration curve:** A graphic representation of the number of times given quantities of flow are equaled or exceeded during a certain period of record.

**Fragipans**: A natural subsurface soil horizon seemingly cemented when dry, but when moist showing moderate to weak brittleness, usually low in organic matter, and very slow to permeate water.

**Gage stations:** The site on a stream or lake where hydrologic data is collected.

**Gradient plots:** A graph representing the gradient of a specified reach of stream. Elevation is represented on the Y-axis and length of channel is represented on the X- axis.

**Hydropeaking:** Rapid and frequent fluctuations in flow resulting from power generation by a hydroelectric dam's need to meet peak electrical demands.

**Hydrologic unit (HUC):** A subdivision of watersheds, generally 40,000-50,000 acres or less, created by the USGS. Hydrologic units do not represent true subwatersheds.

**Hypolimnion:** The region of a body of water that extends from the thermocline to the bottom and is essentially removed from major surface influences during periods of thermal stratification.

**Incised:** Deep, well-defined channel with narrow width to depth ration, and limited or no lateral movement. Often newly formed, and as a result of rapid down-cutting in the substrate

**Intermittent stream:** One that has intervals of flow interspersed with intervals of no flow. A stream that ceases to flow for a time.

**Karst topography:** An area of limestone formations marked by sinkholes, caves, springs, and underground streams.

**Loess:** Loamy soils deposited by wind, often quite erodible.

**Low flow:** The lowest discharge recorded over a specified period of time.

**Missouri Department of Conservation (MDC):** Missouri agency charged with: protecting and managing the fish, forest, and wildlife resources of the state; serving the public and facilitating their participation in resource management activities; and providing opportunity for all citizens to use, enjoy, and learn about fish, forest, and wildlife resources.

**Missouri Department of Natural Resources (MDNR):** Missouri agency charged with preserving and protecting the state's natural, cultural, and energy resources and inspiring their enjoyment and responsible use for present and future generations.

**Mean monthly flow:** Arithmetic mean of the individual daily mean discharge of a stream for the given month.

**Mean sea level (MSL):** A measure of the surface of the Earth, usually represented in feet above mean sea level. MSL for conservation pool at Pomme de Terre Lake is 839 ft. MSL and Truman Lake conservation pool is 706 ft. MSL.

**Necktonic:** Organisms that live in the open water areas (mid and upper) of waterbodies and streams.

**Non-point source:** Source of pollution in which wastes are not released at a specific, identifiable point, but from numerous points that are spread out and difficult to identify and control, as compared to point sources.

**National Pollution Discharge Elimination System (NPDES):** Permits required under The Federal Clean Water Act authorizing point source discharges into waters of the United States in an effort to protect public health and the nation's waters.

**Nutrification:** Increased inputs, viewed as a pollutant, such as phosphorous or nitrogen, that fuel

abnormally high organic growth in aquatic systems.

**Optimal flow:** Flow regime designed to maximize fishery potential.

**Perennial streams:** Streams fed continuously by a shallow water table an flowing year-round.

**pH:** Numeric value that describes the intensity of the acid or basic (alkaline) conditions of a solution. The pH scale is from 0 to 14, with the neutral point at 7.0. Values lower than 7 indicate the presence of acids and greater than 7.0 the presence of alkalis (bases).

**Point source:** Source of pollution that involves discharge of wastes from an identifiable point, such as a smokestack or sewage treatment plant.

**Recurrence interval:** The inverse probability that a certain flow will occur. It represents a mean time interval based on the distribution of flows over a period of record. A 2-year recurrence interval means that the flow event is expected, on average, once every two years.

**Residuum:** Unconsolidated and partially weathered mineral materials accumulated by disintegration of consolidated rock in place.

**Riparian:** Pertaining to, situated, or dwelling on the margin of a river or other body of water.

**Riparian corridor:** The parcel of land that includes the channel and an adjoining strip of the floodplain, generally considered to be 100 feet on each side of the channel.

**7-day $Q^{10}$:** Lowest 7-day flow that occurs an average of every ten years.

**7-day $Q^{2}$:** Lowest 7-day flow that occurs an average of every two years.

**Solum:** The upper and most weathered portion of the soil profile.

**Special Area Land Treatment project (SALT):** Small, state funded watershed programs overseen by MDNR and administered by local Soil and Water Conservation Districts. Salt projects are implemented in an attempt to slow or stop soil erosion.

**Stream Habitat Annotation Device (SHAD):** Qualitative method of describing stream corridor and instream habitat using a set of selected parameters and descriptors.

**Stream gradient:** The change of a stream in vertical elevation per unit of horizontal distance.

**Stream order:** A hierarchical ordering of streams based on the degree of branching. A first order stream is an unbranched or unforked stream. Two first order streams flow together to make a second order stream; two second order streams combine to make a third order stream. Stream order is often determined from 7.5 minute topographic maps.

**Substrate:** The mineral and/or organic material forming the bottom of a waterway or waterbody.

**Thermocline:** The plane or surface of maximum rate of decrease of temperature with respect to depth in a waterbody.

**Threatened:** A species likely to become endangered within the foreseeable future if certain conditions continue to deteriorate.

**United States Army Corps of Engineers (USCOE) and now (USACE):** Federal agency under control of the Army, responsible for certain regulation of water courses, some dams, wetlands, and flood control projects.

**United States Geological Survey (USGS):** Federal agency charged with providing reliable information to: describe and understand the Earth; minimize loss of life and property from natural disasters; manage water, biological, energy, and mineral resources; and enhance and protect the quality of life.

**Watershed:** The total land area that water runs over or under when draining to a stream, river, pond, or lake.

**Waste water treatment facility (WWTF):** Facilities that store and process municipal sewage, before

release. These facilities are under the regulation of the Missouri Department of Natural Resources.

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